Study Title

Compilation of Published Product Performance Data of Bear Deterrent Sprays for Frontiersman® Bear Attack Deterrent

Company Name

Security Equipment Corporation

Product Identification

Frontiersman® Bear Attack Deterrent
EPA File Symbol: ________-_____
[Capsaicin and related capsaicinoids @ 1.388%]

Data Requirement

Pesticide Assessment Guidelines
Subdivision G: Product Performance
Guideline Number 96-1
40 CFR 158.640

Compiled By

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STATEMENT OF NO DATA CONFIDENTIALITY CLAIMS

No information contained in this study is claimed as confidential on the basis of its falling within the scope of FIFRA Section (10)(d)(1)(A), (B) or (C).

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GOOD LABORATORY PRACTICE STATEMENT

This study is a compilation of published reports of which the submitter was not the sponsor..

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SUMMARIES

Field Use of Capsicum Spray as a Bear Deterrent

Abstract: The researchers analyzed 66 cases of field use of capsicum sprays between 1984 and 1994. In 94% of the close-range encounters with aggressive brown (grizzly) bears (*Ursus arctos*), the spray appeared to stop the behavior that the bear was displaying immediately prior to being sprayed. In 6 cases the bear continued to act aggressively; in 3 of these cases the bear attacked the person spraying. In 1 of these 3 cases, the bear left after further spraying. In all 3 injurious encounters the bear received a substantial dose of spray to the face. In 88% (14/16) of the cases, the bear eventually left the area after being sprayed. While the authors do not know how these encounters would have ended in the absence of spray, the use of spray appears to have prevent injury in most of these encounters. In 100% (20 of 20) of the encounters with curious brown bears or bears searching for people's food or garbage the spray appeared to stop the behavior. The bear left the area in 90% (18 of 20) of the cases. In only 2 of these 18 cases was it known to have returned. In 100% (4 of 4) of the encounters with aggressive and surprised, or possibly predacious black bears (*Ursus americanus*) the spray appeared to stop the behavior that the bear was displaying immediately prior to being sprayed. However, no bears left in response to being sprayed. In 73% (19 of 26) of the cases associated with curiosity, the spray appeared to stop the behavior. The bear left the area in 54% (14 of 26) of the cases, but in 6 of these 14 cases it returned. In 62% (8 of 13) of the incidents where the black bear received a substantial dose to the face it either did not leave the area or left the area and returned. Sprays containing capsicum appear to be potentially useful in a variety of field situations; however, variable responses by bears occur. Because the database is composed of diverse field records the results should be viewed with caution.

Behavioral Responses of Bears to Tests of Repellents, Deterrents and Aversive Conditioning

Laboratory results indicate that stimuli can be developed that will repel most bears. Halt, a product containing capsaicin, and a bear Skunker (synthesized skunk spray)/Halt combination were highly repellent stimuli. Inclusion of an odor cue with a repellent stimulus seemed to increase its effectiveness. Effective stimuli appeared to reduce aggression and the frequency of immediate charges in a subsequent encounter. Canisters with more concentrated solutions (than Halt) of capsaicin and longer, wider spray distances should be developed. By simultaneously combining additional visual, odor or auditory cues with the use of the capsaicin, many bears may be repelled from approaching during initial or subsequent encounters without direct application of the spray.

#3/6

FIELD USE OF CAPSICUM SPRAY AS A BEAR DETERRENT

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Abstract: We analyzed 66 cases of field use of capsicum sprays between 1984-94. In 94% (15 of 16) of the close-range encounters with aggressive brown (grizzly) bears (*Ursus arctos*), the spray appeared to stop the behavior that the bear was displaying immediately prior to being sprayed. In 6 cases, the bear continued to act aggressively; in 3 of these cases the bear attacked the person spraying. In 1 of these 3 cases, the bear left after further spraying. In all 3 injurious encounters, the bear received a substantial dose of spray to the face. In 88% (14/16) of the cases, the bear eventually left the area after being sprayed. While we do not know how these encounters would have ended in the absence of spray, the use of spray appears to have prevented injury in most of these encounters. In 100% (20 of 20) of the encounters with curious brown bears or bears searching for people's food or garbage the spray appeared to stop the behavior. The bear left the area in 90% (18 of 20) of the cases. In only 2 of these 18 cases was it known to have returned. In 100% (4 of 4) of the encounters with aggressive and surprised, or possibly predacious black bears (*Ursus americanus*) the spray appeared to stop the behavior that the bear was displaying immediately prior to being sprayed. However, no bears left in response to being sprayed. In 73% (19 of 26) of the cases associated with curiosity, the spray appeared to stop the behavior. The bear left the area in 54% (14 of 26) of the cases, but in 6 of these 14 cases it returned. In 62% (8 of 13) of the incidents where the black bear received a substantial dose to the face, it either did not leave the area or left the area and returned. Sprays containing capsicum appear to be potentially useful in a variety of field situations: however, variable responses by bears occur. Because the database is composed of diverse field records, the results should be viewed with caution.

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The number and rate of injuries inflicted by brown bears and American black bears to people appear to be generally accepted as part of having bears and the natural environments that support them and other wildlife. However, because of the tragedy of some bear-inflicted injuries, we will continue to try to reduce the chances of bear-inflicted injury (Herrero 1985). One possible means of decreasing bear-inflicted injuries would be to use a deterrent. Ideally a deterrent would be highly effective against bears but would not permanently injury bears or people. We present results of field use of sprays containing capsicum pepper derivatives as their active ingredient and deployed when bears were acting aggressively toward people, or were demonstrating other undesirable behavior.

The physiological effects of capsicum (*Capsicum* spp., family Solanaceae) derivatives on various animals have been studied (Miller 1980, Hunt 1984, Rogers 1984). Osol et al. (1967) describes capsaicin (a common derivative of capsicum) as a powerful local irritant of sensory nerve endings, but causing no blisters. Capsicum causes significant inflammation of certain soft tissues, especially the eyes and respiratory tract of human beings (M. Stalder, Anza Borrego Desert State Park, Borrego Springs, Calif., pers. commun., 1995). In people, capsicum spray can cause involuntary closing of the eyes, and temporary loss of muscular strength and coordination. Products containing capsicum are now used in police work against aggressive people. Most researchers conclude that the powerful local effects are temporary on all animals that have been tested, including bears and people (see Rogers [1984] for a review). One human death was, however, caused (11 July 1993 in Concord, N.C.) by police use of oleoresin capsicum on a "combatant" (M. Stalder, Anza Borrego Desert State Park, Borrego Springs, Calif., pers. commun., 1995). The autopsy revealed that the deceased probably had several predisposing conditions, including a "significant underlying pulmonary condition." The spray can also get into the pores of soft contact lenses and can be impossible to completely remove.

When used as a bear deterrent in controlled laboratory tests, and in limited field tests, sprays containing 10% capsicum derivative as their active ingredient have generally stopped the behavior evidenced immediately prior to spraying. This was true for laboratory-induced aggression in both brown bears and black bears (Miller 1980, Hunt 1984). Field testing of capsicum spray on aggressive bears has not been previously reported. Rogers (1984) successfully deterred non-aggressive black bears from baits in field tests, but he had a very small sample, $n = 5$. Hunt (1984) reported that black bears were repelled from food baits in 18 of 21 field tests; however 86% of the animals returned and resumed foraging an average of 17 minutes later. Because bears are behaviorally complex, individual differences in response to being sprayed are expected (Rogers 1984, Herrero 1985). Importantly, no one has reported that use of capsicum spray on either black or brown bears resulted in increased aggression.

Our research used data from throughout North America regarding field use of capsicum sprays on either aggressive, curious, or human-food conditioned brown bears or black bears. Despite a lack of experimental controls, we assumed that the response of bears to being sprayed is detectable. We also propose that the case history approach is the most effective means of studying the response of free-ranging, aggressive brown bears to being sprayed.

We thank the people who provided us with the field records on which our data are based. A special thanks is owed to Rick Potts and Brian Holmes of Katmai National Park for providing a number of well-documented records of interactions in the Brooks River area. We also thank Cappy Gagnon of Counter Assault Personal Defense Sprays for sharing descriptions of the spray use that had been sent to him.

METHODS

As part of a broader study of bear-human interactions, we sent inquiries to 235 agencies throughout Canada and the United States that either had responsibility for bear management or whose personnel frequent bear habitat. We requested records of field use of aerosol sprays containing extracts of capsicum as a deterrent against bears. In addition to agency reports of such use, we directly contacted individuals who because of newspaper reports or word of mouth, we believed had used capsicum spray as a bear deterrent.

We analyzed reports of capsicum spray use on bears by entering each incident into a computer database. Such reports are subject to various recording and interpretation errors and to the problem of trying to adequately represent complex, real-world situations (with many variables complexly interwoven) in a form permitting analysis. Such errors and uncontrolled variables create "noise" in the database, but with our sample size we assume that patterns of response by bears to use of capsicum spray as a deterrent emerge as an approximation of free-ranging bears' actual responses to being sprayed. Because these incidents were not part of a controlled experimental design, we did not statistically analyze the data since results should be viewed with caution given the lack of controlled methodology. One inconsistency is that various capsicum sprays were used in the field situations. Variations between brands could not be systematically investigated because of small sample sizes for all brands except Counter Assault (Bushwacker Backpack and Supply Co., Missoula, Mont.) ($n = 50$). All sprays used in situations included in our database likely contained 10% capsicum extract as their active ingredient.

We grouped data by bear species and by the behavior or inferred motivation of the bear in the incident. For both black and brown bear incidents, we recognized 2 types of incidents. In 1 type, the bear's behavior prior to being sprayed appeared to be searching for food or garbage or being curious. When aggression was involved it seemed to be directed toward obtaining food or garbage. Often such incidents took place in developed portions of parks and the bear probably had a history of feeding on people's food (including just-caught fish) or garbage. In the second type of incident, people perceived that the bear was acting aggressively prior to being sprayed, without the element of food or garbage. These incidents included bear behaviors such as charging, making aggressive noises, or persistent following.

RESULTS

We analyzed 66 cases of field use of capsicum sprays. Brown bears were involved in 36, black bears in 30. Incidents occurred primarily in Alaska, British Columbia, Montana, and Alberta.

Delivery of Spray to the Bear.—We separated the incidents into 3 classes: cases where the bear was reported by the sprayer to have received a substantial dose to the face, cases where it reportedly did not, and cases where the dose was not determined. Although we did not apply any statistical tests, no obvious differences in response were apparent between these subsets and therefore we pooled data. In slightly more than half of the incidents, the person using the spray reported that the bear received a substantial dose of spray to the face.

Brown Bears Acting Aggressively.—In 81% (13 of 16) of these incidents the person reported not being aware of the bear until it was < 50 m away, however, in 2 incidents the bear or bears involved were first sighted at > 200 m. In 88% (14/16) of the cases the bear charged at the person or people. In 62% (10 of 16) of the incidents, a female bear with offspring (ages varied) was involved, and in 6 only a single bear was seen. Only 1 incident was known to have involved an adult male bear.

In 94% (15 of 16) of the cases, use of the spray was associated with the bear stopping its aggressive behavior. In 38% (6 of 16) of the cases, the bear either continued to act aggressively (1 of 16) or briefly stopped but then resumed its aggressive behavior (5 of 16). In 3 of these cases, the bear attacked and injured the person using the spray. In 2 cases the person spraying required <24 hours of hospitalization; the other required >24 hours of hospitalization. In 1 of these 3 cases further spraying appeared to have caused the bear to leave. Of the 3 incidents that resulted in injury to the person using the spray, 2 involved a female with one or more cubs, and the other involved a single, adult male. In all 3 injurious encounters, the bear received a substantial dose of spray to the face at close range. In 2 incidents, the person was injured after spraying a bear that was attacking a companion. Here the approach by the sprayer, combined with the spraying, redirected the attack to the person spraying. In 88% (14 of 16) of the cases the bear left the area after being sprayed. These included incidents where the bear continued to act aggressively after the first spraying and did not leave until after the second or third spraying. In 12% (2 of 16) of the cases the bear remained and the person left the area.

Brown Bear Acting Curiously or Searching for People's Food or Garbage.—In each of these cases the bear involved was either not acting aggressively prior to being sprayed (80%, 16 of 20) or the aggression involved a direct approach apparently aimed at getting a person's food, such as a fish (20%, 4 of 20). The bear was, however, behaving in a way that the person using the spray found undesirable. In 80% (16 of 20) of these cases, only a single bear was involved. In the other 20% (4 of 20) cases, a sibling pair or larger sibling group was involved. In total, 85% (17 of 20) of the incidents involved subadult bears. In 100% (20 of 20) of the cases, use of the spray was associated with the bear stopping the undesirable behavior immediately after being sprayed. The bear left the area immediately after being sprayed in 90% (18 of 20) of the incidents. In only 2 of these cases was the bear known to have returned. In 38% (3 of 8) of the incidents where the bear did not receive a substantial dose of spray to the face, the people involved reported that the bear was apparently deterred by the sound of the spray discharging and the spray cloud.

Black Bears Acting Aggressively.—In 3 of 4 cases a black bear either charged (2 cases) or vocalized aggressively and then approached (1 case). All three of these cases appeared to involve responses to 1 or 2 people suddenly being within 50 m of 1 or 2 black bears. In 1 case the aggressive bear may have been 1 member of a pair of black bears engaged in courtship. In the fourth case, the bear exhibited predatory behavior as defined by Herrero (1985) and Herrero and Higgins (1995). The bear saw the people involved, followed them for several minutes, and then approached quietly.

In all of the 4 incidents the spray apparently changed the behavior of the bear; however, in no cases did the bear leave the area after being sprayed. In 1 case the bear was shot and killed after being sprayed. In another case the bear left after a shotgun was fired. In the other 2 cases the person left. In 1 the bear didn't follow, but in the other the bear followed and the person was finally able to make it to camp, but only after firing a bear banger. No people were injured.

Black Bears Acting Curiously or Searching for People's Food or Garbage.—As with brown bears, in this type of incident prior to being sprayed the black bear was either not acting aggressively (85%, 22 of 26) or the aggression seemed to be directed at obtaining food or garbage (15%, 4 of 26). In 92% (24 of 26) of these cases only 1 bear was seen. In the other 8% (2 of 26) of incidents, a female bear with 1 or more cubs was involved. In 73% (19 of 26) of this type of incident the spray had the apparent effect of changing the behavior. In the other 27% (7 of 26) of cases, the spray elicited varied and sometimes unclear responses. In 2 of these cases, the bear showed no apparent response to being sprayed. The bear left the area after being sprayed in 54% (14 of 26) of the cases, however in 6 of these 14 cases the bear returned. In 62% (8 of 13) of the incidents where the bear received a substantial dose to the face, it either did not leave the area or it left and returned.

Environmental Conditions and Spray Application.—In 9% (6 of 66) of incidents, the sprayer reported that environmental conditions interfered with the application of the spray. In 4 of these incidents, there was a headwind or crosswind. In the fifth incident, heavy rain quickly dispersed the spray. In the sixth incident, thick bushes limited the size of the spray cloud. None of the incidents involved injury. However, in 2 incidents involving a headwind, the person using the spray had it blown back on him and was affected by it. To deliver a substantial dose of spray to the bear under typical conditions, most sprayers reported having to be within 6 m of the bear, with greater success from within 3 m.

Mechanical Problems with Spray Canisters.—In 3% (2 of 66) of incidents, the sprayer reported some mechanical deficiency with the spray. In 1 incident, the spray released from the canister in a stream-like shot rather than as a mist or fog. In another incident, the canister lost pressure and some of the contents dribbled down its side. The sprayer thought the canister was clogged, but it may have been empty. Neither of these incidents involved injury. In a third incident, the sprayer was injured by a brown bear when the can emptied during the bear's charge.

DISCUSSION AND CONCLUSIONS

Our results are consistent with tests conducted on a small number of captive grizzly bears (Miller 1980, Hunt 1984) and on captive (Hunt 1984) and free-ranging black bears (Hunt 1984, Rogers 1984). Capsicum spray appeared to be reasonably, but not 100% effective as a deterrent against free-ranging, aggressive brown bears. Many of the cases we studied involved female brown bears apparently defending their young and responding to a person suddenly sensed nearby, although in 2 cases the bear family was first seen at > 200 m. In most cases the bear or bears involved responded by charging. In 6 of 16 cases the bear continued to act aggressively after being sprayed. In a minority of instances, despite receiving a full dose of spray to the face, the bear inflicted injury to the person using the spray. Despite a small number of people being injured after spraying an aggressive brown bear, in no cases did use of the spray appear to be responsible for increasing the extent of injury.

We do not know how a given incident might have ended without use of the spray. Herrero (1985) reported that most brown bear charges did not result in contact or injury when spray was not used and that black bears often charged people but very rarely contacted and injured them.

One caution regarding generalizing our results is that in the 1 instance where capsicum spray was known to have been used on an adult female grizzly bear with cubs that charged from a nearby ungulate carcass, injury to the sprayer resulted. For certain individual brown bears, the spray may not be effective if the bear is encountered at close range and near a carcass.

Capsicum spray very effectively deterred free-ranging brown bears approaching people out of curiosity or to get at their food (including fish) or garbage. These bears which were primarily sub-adult, stopped their undesirable behavior and left the area. In 2 cases, however, the bear returned. The success of capsicum spray to deter adult, free-ranging brown bears in this context is unknown.

Because there were only 4 instances of spray use on free-ranging aggressive black bears, results should be viewed with caution. The spray appeared to be less effective than when used in aggressive incidents with brown bears. All black bears stopped what they were doing when sprayed, but none left the area immediately. Whether the spray would be effective against potentially predaceous black bear remains unanswered.

Rogers (1984) reported clear-cut aversive responses in 5 free-ranging black bears that he sprayed with capsaicin while they were approaching food he set out in a campground or garbage dump. With a significantly larger sample (n = 21) Hunt (1984) found that most bears were repelled from food baits after being sprayed but most of them also returned a short while later. Our findings regarding curious black bears or bears searching for people's food or garbage (and presumably already food-conditioned and habituated to people) were unclear. In about half of the 26 cases we studied, the bear either did not leave or it left and returned a short time later. These results show that at least for black bears, there does not appear to be an overwhelming physiological response that might cause bears to leave after being sprayed. The response to spraying might depend on the degree of food-conditioning or individual differences between bears.

Our results raise the possibility that black and brown bears have different responses to capsicum spray. The uncontrolled nature of our database does not allow further comment.

Spray dispersal into a cloud rather than a narrow stream appears to be beneficial for 2 reasons. First, the formation of the cloud (and the noise made by discharge from the canister) may in some instances be a deterrent independent of any of the spray actually reaching the bear. Second, this pattern of dispersal saves the sprayer from having to accurately direct the spray at a charging bear in what is a high-stress situation. Use of the spray does not require the training or experience needed to shoot accurately at a charging bear with a rifle or a shotgun.

The spray canisters in this data set were generally mechanically reliable. Users should be aware that mechanical failures can occur and should familiarize themselves with what to do in the event of an aggressive encounter in which the canister malfunctions or otherwise doesn't deter aggression. Users may wish to test the canister with a brief spraying to ensure that the propellant works and to become familiar with the dispersal pattern of the spray.

Users should consider environmental conditions when using the spray. The ability to deliver a sufficient amount of spray to the bear may be limited in conditions of moderate or high wind, heavy rain, or thick vegetation. If the wind blows capsicum into the user's face, this could make it difficult to either play dead, or fight back, both appropriate responses in certain types of bear incidents (Herrero 1985). Conversely, if a person can maneuver upwind of the bear, the wind may assist in delivering spray to the bear. Capsicum is believed to exert its primary effect on soft tissue, causing inflammation of the eyes and inflammation and constriction of the respiratory tract (M. Stalder, Anza Borrego Desert State Park, Borrego Springs, Calif., pers. commun., 1995, Rogers 1984). For this reason, spray should be directed at the bear's face.

We believe that bears' responses to the spray are not solely a function of the dose received. A substantial dose of spray to the face was not sufficient to deter the bear in a number of incidents. Study of the 3 incidents involving injury to the person using the spray showed that the person had delivered a substantial dose to the bear's face before being injured. In other incidents, the bear was successfully deterred even though it did not receive a substantial dose of spray to the face. Aggressive encounters between bears and humans are complex events influenced by a large number of variables. We believe this to be true regardless of whether capsicum spray is used—capsicum does not appear to become the sole variable influencing behavior after spraying.

We conclude that sprays containing capsicum appear to be useful in a variety of field situations when used on free-ranging brown bears. Our results show an acceptable level of effectiveness and that injury will sometimes occur despite effective deployment of the spray. When used on aggressive black bears our data only cover a small sample (n = 4). For the remaining incidents that deal primarily with habituated and food-conditioned black bears, the sample was much larger (n = 26) but results were variable. We recommend further testing through documented field use and other means.

An increasing number of people are buying spray containing capsicum for possible use against aggressive bears. This is reasonable as the spray may prevent or limit injury to people and bears. However, as Dr. Stephen French, a grizzly bear researcher in the Yellowstone Ecosystem says, "the spray isn't brains in a can." Carrying bear spray is not a substitute for the normal precautions when traveling or camping in bear country (Rogers 1984, Herrero 1985).

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BEHAVIORAL RESPONSES OF BEARS

TO TESTS OF

REPELLENTS, DETERRENTS, AND AVERSIVE CONDITIONING

by

Carrie L. Hunt

B.S., Montana State University, 1977

A Thesis in partial fulfillment of
the requirements for the degree of

Master of Science

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Behavioral Responses of Bears to Tests of Repellents, Deterrents, and Aversive Conditioning.

Director: C. J. Jonkel *CJ*

Most human-bear conflicts are caused by surprise encounters and bear use of human foods. Investigated were repellents and deterrents with the potential to reduce conflicts. Repellents were tested on 5 captive black bears (Ursus americanus) and 1 captive grizzly bear (U. arctos) as the bears charged or approached humans. Tested were Halt (capsaicin product), Bear Skunker (simulated skunk spray), Shield (mace product), an air horn, railroad flares, a quickly-opened umbrella, and taped music and bear sounds. Most bears were repelled by Halt or a Bear Skunker/Halt combination. Bears repelled during a test were less likely to be aggressive during the next test. Certain bears that seemed inherently non-aggressive were frequently repelled by stimuli that incited charges by more aggressive individuals. Also discussed are intention movements by bears, and similar movements by humans that appeared to have signal value for bears.

Repellents were delivered to 2 black bears and 2 grizzly bear cubs, aimed at aversively conditioning the bears to avoid humans. These bears were subsequently released into the wild. None is known to have caused further problems or to have been killed through hunting or control actions. Important contributing factors may have been the non-aggressive temperament of each of the bears and the timing of their release.

Deterrents and repellents were tested on approximately 31 free-ranging black bears visiting baits at a sanitary landfill. Tests of taste and odor deterrents included ammonia, male and female human urine, mothballs, Bear Skunker, Boundry (dog deterrent), and Technichem (bear deterrent). Full strength Parson's ammonia and male human urine placed on baits deterred most bears from eating; only ammonia appeared to deter many bears from approaching baits. Pain-inducing repellents triggered by remote control were Bear Skunker and Halt. Halt repelled most bears from the site temporarily. Test responses were the result of the effect of a stimulus on the individual bear, dominance activities by other bears at the site, and the availibility of natural foods in the area. Certain bears appeared to tolerate the more noxious deterrents or returned repeatedly following tests of the triggered repellents.

Presented as an appendix is an extensive bibliography entitled Deterrents, Aversive Conditioning, and Other Practices: An Annotated Bibliography To Aid In Bear Management.

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GENERAL INTRODUCTION

Conflicts between bears and people have increased in frequency as logging, tourism, and exploration for oil and gas have developed in areas used by bears (Jonkel 1970, Schweinsburg 1976). Escalating human-bear problems in the National and Provincial parks of the United States and Canada have been correlated with increases in the number of people visiting the parks, and the unnatural foods made available to the bears by visitors (Herrero 1970, 1970a, 1976, Mundy and Flook 1973, Singer and Bratton 1980, Hastings and Gilbert 1981).

"Bears are omnivorous and highly intelligent, possessing both a genetic and learned ability to utilize resources and deal with environmental change" (Eager and Pelton 1979). They are generally the most dominant non-human members of the communities in which they are found. Encounters with bears are inherently dangerous because of their size and strength. Because their ecological niche has many similarities with that of humans, the potential for conflicts will always exist in areas used by both humans and bears.

Control of human-bear conflicts has commonly involved relocation or destruction of the offending bear. These methods have proven to be ineffective solutions to most problems (Herrero 1976, Jorgensen et al. 1978, Eager and Pelton 1979). State and federal agencies are under growing public pressure to reduce or solve bear problems. With increasing frequency, management agencies are emphasizing the importance of methods that allow humans and bears to coexist. Interest is high in repellents and deterrents to prevent bears from approaching humans, settlements, campgrounds, and garbage dumps. The development of methods that prevent conflicts may be critical to the survival of grizzly bears (Ursus arctos) in the contiguous 48 states.

Efforts to repel or deter wildlife species have focused on insects, birds, deer, and most recently on coyotes; relatively few studies have been conducted on bears. Where applied, preventative measures such as electric fences, bells for hikers, and bear-proof campgrounds and garbage sites, have reduced conflicts (Parks Canada 1972, Herrero 1976, Meagher and Phillips 1980, Hastings and Gilbert 1981, Jope 1982).

Approaches to repellent and deterrent methods should use knowledge of predictable bear behavior from an ecological perspective, with particular focus on bear behavior as it relates to the effect of the food base on a population. The nature and extent of human activity in an area, and the perceptive abilities of the bear, will dictate the choice of repellent or deterrent used (Dorrance and Gilbert 1977).

Both repellents and deterrents must elicit avoidance behavior. A review of the literature revealed a general lack of distinction between the 2 terms and subsequent inconsistencies in their use. The 2 principal situations that cause human-bear conflicts are surprise encounters and bear use of human food sources. With these applications in mind the terms are distinguished as follows within the text of this manuscript:

1. Repellents are activated by humans and should immediately turn a bear away during a close approach or attack.

2. Deterrents should prevent undesirable behaviors by turning bears away before a conflict occurs, such as bears approaching camps, orchards, or garbage dumps. They need not be monitored or manually activated by humans.

3. Aversive conditioning should modify previously established, undesirable behavior through the use of repellents or deterrents. The conditioning must be repeated until avoidance of people or their property has been firmly established.

The purpose of this study was to develop test procedures and to test repellents and deterrents that could reduce bear-human encounters and conflicts. A series of studies conducted in Canada by students from the Universities of Guelph and Montana, in association with the Border Grizzly Project, provided background data for this research (Best 1976, Cushing 1980, Miller 1980).

The objectives of the project were to:

1. systematically test substances or devices on grizzly bears and black bears (_U. americanus_) that may a) repel bears and can be carried and used by persons likely to encounter bears or b) deter bears and can be left at sites (e.g. camps, cabins, garbage dumps, orchards) to prevent close approaches by bears;

2. describe the behavioral responses of captive bears to tests of potential repellents; and

3. describe the behavioral responses of free-ranging bears to tests of repellents that produced promising responses in the laboratory tests, and to potential repellents and deterrents not appropriately tested under laboratory conditions.

Tests were conducted on snared bears in the wild, on captive bears in a laboratory at Fort Missoula, Missoula, Montana, and on free-ranging bears at a sanitary landfill site at Sparwood, British Columbia. Parts I, II, and III, respectively present the results of the repellent tests on captive bears, aversive conditioning of captive bears, and repellent and deterrent tests on free-ranging bears. Each part is written in a format suitable for publication. General conclusions and management recommendations are presented in Part IV.

As a necessary step toward developing effective research programs in the future and for this study, an annotated bibliography was compiled on deterrents, repellents, aversive conditioning, and other practices that may aid in bear management. The manuscript is included as Appendix 16. The purpose of the compilation is to provide a resource that will be useful to managers and researchers in decision-making and research planning. Its inclusion in this thesis is to provide further background information and to allow for greater distribution.

PART I

TESTS OF REPELLENTS ON CAPTIVE BEARS

Incidences of human injury caused by bears have increased throughout North America (Herrero 1976, Schweinsburg 1976, Singer and Bratton 1980, Hastings et al. 1981, Jope 1982). Rising injury rates reflect increases in human activities in backcountry areas, and in the use of unnatural food sources by bears, both of which raise the chances for bear-human encounters (Mundy and Flook 1973, Herrero 1976, Eager and Pelton 1979, Singer and Bratton 1980, Hastings and Gilbert 1981). Although incidences are low relative to the potential that exists, the trend is symptomatic of growing problems that must be dealt with if humans are to co-exist with natural populations of bears.

Most attacks on humans have been precipitated by people either intentionally or unintentionally getting too close to bears. Bears will attack when surprised, protecting their young, or guarding their food (Jonkel and Servheen 1977). The majority of documented attacks have involved bears that had received "handouts" or fed on human garbage (Eager and Pelton 1979, Follman et al. 1980, Hastings et al. 1981).

Management efforts should minimize the potential for human-bear confrontations. Many parks have significantly reduced bear problems through public education, trail or campground closures, trail rerouting, and garbage management (Martinka 1974, Herrero 1976, Meagher 1980, Hastings et al. 1981). Further preventive efforts should be aimed at reducing or eliminating conflict during an encounter.

The frequency of encounters between competing dominant and subdominant species determines their distribution and densities (Nagy and Russell 1978). This mechanism appears to operate both intra- and interspecifically, affecting grizzly (Ursus arctos) and black bear (U. americanus) populations competing for space and resources (Herrero 1972, 1978, Martinka 1976). Avoidance and tolerance between bears appears to be based on a loose social hierarchy established through aggression and size. Dominance is settled during the first few encounters and thereafter is maintained primarily through visual signals (Hornocker 1962, Egbert and Stokes 1976, Rogers 1977, Herrero 1980).

Interspecific relationships between grizzly and black bears may have considerable relevance to human-bear co-existence. Some evidence suggests that bears defer to people in the same manner as they do dominant bears (Herrero 1970a, Jonkel 1978). Bears generally try to avoid humans (Jonkel 1970, Martinka 1976). Jope (1983) found that grizzlies made no charges at hikers wearing bells. Most injuries have been partially attributable to improper behavior by people (Eager and Pelton 1979, Herrero 1980, Jope 1982). Repellents and deterrents, perhaps used in conjunction with correct body movements by humans, could serve as visual, auditory, or olfactory signals for bears. Application of effective repellents and deterrents during human-bear confrontations may play an important role in establishing and maintaining human dominance over bears, or at least in maintaining stable relationships.

Ideally, when activated, effective repellent stimuli and practices must: a) immediately stop an undesirable behavior and turn a bear away during an encounter, regardless of the animal's motivation, temperament, or past history of encounters with people; b) not allow a second approach or cause increased aggression during subsequent encounters with humans; and c) not cause permanent physical damage to the bear.

A variety of repellents have been tried on captive and free-ranging bears, but few of the results have been documented. Tests of acoustic repellents suggest only limited value during a close encounter or attack, although biologically meaningful sounds may prove more useful with further study. Approaches to the use of sound should be aimed at using sharp, loud sounds, biologically significant sounds, or combinations of sound with other stimuli (Frings and Frings 1963, Haga 1974, Schweinsburg and Smith 1977, Wooldridge and Belton 1980, Miller 1980).

Reports on the effectiveness of visual repellents, such as specific human activities during an encounter, are generally anecdotal, but show promise. Many National Park Service bear-human interactions have been categorized and evaluated (Herrero 1976, Tate and Pelton 1979, Hastings

1982, Jope 1982, Tate 1983). Miller (1980) successfully repelled captive bears using a "loom" stimulus (lm by lm square plywood board quickly turned broadside). Such stimuli may be most effective in combination with auditory or chemical stimuli that provide additional cues and that address more than 1 sense.

Most commonly, tests of noxious chemicals and natural repellents on bears have involved lachrimating agents. Few tests of riot control agents (such as Mace) have been conducted. The primary reason for this has been the possibility of permanent lung, eye, or skin damage, which appears dependent on dosage, manner of application, and duration of exposure (Cucinell et al. 1971, Gaskins et al. 1972). However, Wooldridge (1978) hypothesized that long-term effects on unrestrained animals would be minimized because the blink reflex deflects much of the spray. Some evidence suggests that animals may become enraged following exposure (Follman et al. 1980).

Promising results have been achieved using a dog repellent spray containing capsaicin ("Halt", Animal Repellents, Griffin, GA). Limited tests have been conducted on captive black bears (Follman et al. 1980), grizzly and polar bears (Ursus maritimus) (Miller 1980), and free-ranging black bears (L. Rogers 1983 pers. comm.). All bears retreated and no aggressive responses were noted.

The objectives of this study were to:

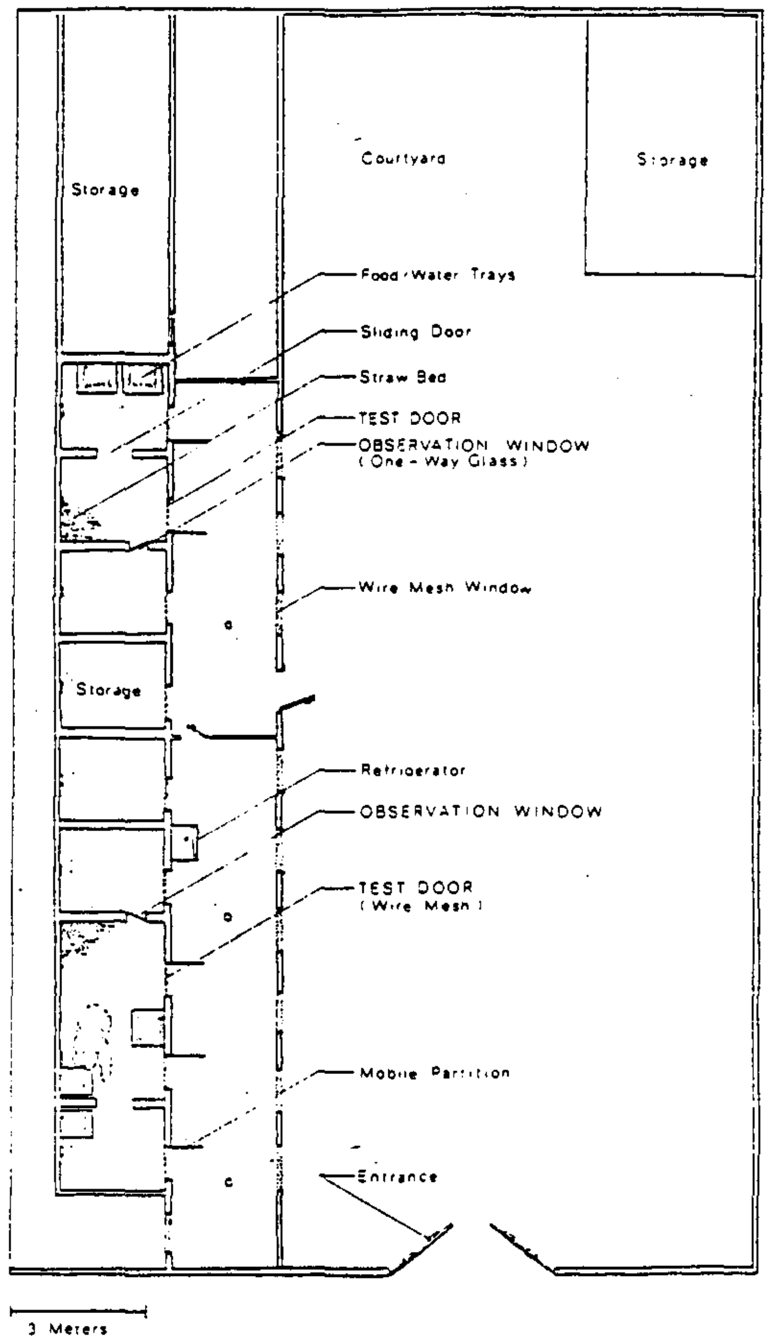
1. systematically test substances or devices that may repel bears and that can be easily carried and used by persons likely to encounter bears; and

2. describe the behavioral responses of captive bears to tests of various claimed or potential repellents.

METHODS AND MATERIALS

In 1981, several tests were conducted on bears restrained in the wild by Aldrich Leg-hold Snares with approximately 4m of cable lead. When construction of a laboratory was completed in an old prisoner-of-war housing unit at Fort Missoula, Missoula, Montana, tests were thereafter conducted at this facility (Fig. 1). Cells in the east wing of the unit were converted into a laboratory; the rest of the building remained unused except for storage. The location and construction of the laboratory provided complete visual isolation, and adequate auditory and olfactory isolation for the tests. To preclude visual contact with bears other than during test sessions, mobile partitions in the hallways, sliding drop-doors inside the cages, and 1-way mirrors were routinely used when feeding bears, cleaning cages, and observing tests. Laboratory windows were left open to allow air to circulate; bears apparently habituated quickly to most of the sounds and odors that filtered in from the outside. Cell lights were

Fig. 1. Floor plan of the Fort Missoula laboratory.


Storage
Courtyard
Storage
Food/Water Trays
Sliding Door
Straw Bed
TEST DOOR
OBSERVATION WINDOW
(One-Way Glass)
Wire Mesh Window
Storage
Refrigerator
OBSERVATION WINDOW
TEST DOOR
(Wire Mesh)
Mobile Partition
Entrance
3 Meters

controlled by an electronic timer to approximate and supplement normal daylight hours.

The studies on captive bears were designed to test claimed or potential repellents in a "charging bear" situation. Repellents tested were fear-provoking stimuli (Appendix 1). During 1981, certain stimuli that gave strong or moderate responses during Miller's (1980) study were re-tested on 2 black bears. During 1982, based on the pilot tests of 1981, tests were conducted on 4 black bears and 1 grizzly bear.

Bears used in the studies were acquired through interagency cooperation. These were problem animals captured because they had damaged livestock or other property, and were destined to be destroyed or relocated (Appendix 2).

Tests were conducted by an "observer" and a "tester." The observer (presence unknown to the bear being tested) watched the animal and took notes on its behavior before, during, and after tests. The tester approached the bear and attempted to provoke a charge response, whereupon the test stimulus was presented.

When tests were conducted on snared bears in 1981, the observer watched the tests from a blind 10m from the bear, and the tester approached to within 2m of the snared bear and attempted to provoke a charge. Each test stimulus was paired with a water spray test. Paired tests were run approximately 1 hour apart and their order of presentation was varied. Paired sets were run twice a day, approximately 10 hours apart.

During the laboratory tests in 1981 and 1982, the observer watched the animal through 1-way glass from an adjacent cell and video-taped each test; the tester presented the test through a barred test door (Fig. 1). Bears were presented with tests of repellent stimuli, and with control tests where the tester presented himself to the bear in the usual manner, but did not deliver a stimulus if the bear charged.

In the laboratory in 1981, each repellent test was paired with a control test; water spray tests were paired as "controls" with the Halt and Skunker tests. Pairs were presented in random order and tested 1 hour apart. Paired sets were conducted twice a day, 10 hours apart.

In 1982, each bear was presented with at least 2 different repellent stimuli and 1 control. Tests included 4 consecutive repetitions of each stimulus and 4 repetitions of a control. The order of presentation of stimuli were varied for each animal. Two tests were run per day, 10 hour apart (0730 to 0930 and 1730 to 1930); if chemicals were used, the tests were run 24 hours apart (and the test cell was thoroughly scrubbed following the test). Tests of additional stimuli were conducted when possible. These were limited by agency deadlines for destruction of bears or the availability of new bears and limited holding facilities.

The format for testing was as follows:

Day 1 Bears were left alone to acclimate to their cell, and initial responses to caretaking activities were recorded.

Days 2-4 Baseline data on each bear's behavior were recorded at 1 minute intervals by monitoring the bear for 1 hour periods at regularly scheduled test times; no tests were run.

Days 5-15 Bears were tested with repellent stimuli.

Each test was conducted as described below. The observer recorded the bear's behavior for 30 minutes before and after each test. At the scheduled test time, the tester presented himself quietly at the test door for 5 seconds, then attempted to provoke a charge by stomping rhythmically (1 beat every 2 seconds) while standing about 0.5m from the door. Except during control tests, the stimulus was delivered if the bear approached to within 1m of the door, if not, the tester withdrew after 1 minute. Once an approach was elicited and the stimulus delivered, the tester then remained at the door for 30 seconds, continuing to provoke the animal by stomping and allowing time for another approach. If the bear reapproached to within 1m of the door, the stimulus was delivered again.

Responses to tests were recorded and evaluated in the following manner:

1. Bear behavior was recorded for 30 minutes at 1 minute intervals, both before and after each test was presented (Appendix 3, 4, 5, and 6). Recorded behavioral codes (Appendix 6) were adapted from Miller (1980). In this paper, only the bear's overall activity and gross body positions were examined. Overall activity was recorded from quiet to heavy (scaled 1 to 7) and was scored relative to the amount and intensity of movement displayed by each bear (Appendix 6).

2. Bear behavior was video taped from 1 minute before to 1 minute after the tester presented the test.

3. Both the observer and tester wrote long-hand descriptions of the bear's response to the test.

4. During each test the bear's response was scored at 3 points; response to the tester's initial presence, immediate response to the delivered test stimulus, and response to continued provocation by the tester following delivery of the stimulus. These responses were scored according to their type (no response, repel, submissive, aggressive, charge), the angle of orientation to the tester in degrees (0, 1-30, 31-60, 61-90, $\geq$90), and the time (seconds) it took the animal to respond (Appendix 4 and 5). A charge was defined as an approach to within 1m of the test door, and a repel was recorded when a bear retreated farther than 1m from the door and oriented its body at least perpendicularly to the tester ($\geq$90 degrees).

Definitions of aggressive and submissive behavior were subjective, based on knowledge of the individual animal and descriptions from the literature (Hornocker 1962, Henry and Herrero 1974, Egbert and Stokes 1976, Jordan 1976, Pruitt 1974 and 1976, Eager and Pelton 1979).

The small number of bears tested dictated that much of the data analysis be of a qualitative and exploratory nature. Data were compiled on the UM Dec-20 computer system, and analysed with the Statistical Package for the Social Sciences (SPSS, Nie et al. 1975). Descriptions and videotapes of test responses were used to verify recorded test scores and to further evaluate responses.

The intent of this study was to develop a valid testing framework and provide baseline data on which further studies could build. The study is presently continuing using the same format, and at this time the sample size has nearly tripled. These data will be pooled with those of the current study for further analysis.

RESULTS AND DISCUSSION

Responses to Pilot Tests, 1981

Stimuli were tested on Bears 1 and 2 (Appendix 1) while these animals were restrained by foot snares. During 13-16 June, Bear 1 was presented with 4 water spray, 3 Bear Skunker, and 1 Shield tests. On 6 July, Bear 2 received 1 test each of the water spray, air horn, and Bear

Skunker (Appendix 2). This bear was to be relocated, so testing was limited to 1 day.

Reactions to tests were similar for both bears. Initially the bears were reluctant to charge, even when approached closely. Having once charged, they charged quickly during the following test. However, the added negative effect of the snare on the bears' movements appeared to reduce their inclination to recharge during a test, regardless of the stimulus tested. Therefore, responses to continued provocation by the tester were usually submissive.

Tests of the water spray had no effect on either bear (Table 1). Bears would flinch, blink briefly, then continue with no noticeable change in activity.

Bear Skunker seemed to have both immediate and long-term effects on the bears (Table 1). When sprayed, bears blinked rapidly for about 30 seconds and their vocalizations decreased; no further aggressive movements were made toward the tester although they did not attempt to run away. When the tester left the area, bears immediately focused their efforts on trying to escape from the snare. When re-approached during the next test, they behaved in a submissive manner, and could not be provoked into aggression. During subsequent tests, Bear 1 was reluctant to charge when approached by the tester with the Skunker odor.

TABLE 1. Immediate response (%) and continued response (%) of bears to stimuli during 1981.

BEAR	STIMULUS[a]	NUMBER OF TESTS	IMMEDIATE RESPONSE TO STIMULUS				CONTINUED RESPONSE TO TEST			
			Repel	Submissive	Aggressive	Charge	Repel	Submissive	Aggressive	Charge
1 - 1981 (Snared)	Waterspray	4		75	25			100		
	Skunker	3		67	33			100		
	Shield	1			100				100	
2 - 1981 (Snared)	Waterspray	1		100				100		
	Skunker	1		100				100		
	Air horn	1			100					100
1 - 1981 (Laboratory)	Waterspray	2			100				50	50
	Skunker	1	100							100
	Halt	1	100				100			
	Control	3			67	33			33	67
	Bear tape	1				100			100	
	Music	1		100						100
	Air horn	1			100				100	

[a] In order of presentation.

In contrast, when tested with Shield, Bear 1 immediately recharged and continued to display aggressive behavior until the tester left the area. Similarly, Bear 2 reacted to the air horn by becoming more aggressive with each blast, recharging once (Table 1).

During 22-30 July, 1981, additional tests were conducted on Bear 1 in the laboratory at Fort Missoula. Ten tests were run, including 1 each of Bear Skunker, Halt, taped bear sounds, taped music, the air horn, 2 water sprays, and 3 controls.

When initially approached by the tester with Bear Skunker, Bear 1 displayed avoidance and submissive postures. He had not responded this way during the water spray test that preceded this. He apparently remembered the previous noxious effect associated with the odor.

The bear's reactions to application of Skunker were similar to those he had had previously exhibited and to those of Bear 2 when tested while restrained by a snare (Table 1). When the bear charged during the Skunker test, the tester missed the bear's face. The animal turned and ran about 3 feet, then returned and charged again. This time the spray was applied correctly, hitting the bear in the face and eyes. Responding as he had when snared, he made no further aggressive movements toward the tester. Immediately, as the tester left, the bear turned and ran from the room, re-entering a few seconds later. For approximately 24 hours after the test the bear remained quiet and lethargic, eating less than usual. He could not be provoked into aggression toward the tester during the following test.

Halt seemed to have an immediate repellent effect on him, but no long-term effect (Table 1). When sprayed, the bear immediately turned and ran about 2.5m, blinking his eyes rapidly, then stopped and looked over his shoulder at the tester for about 4 seconds. He then returned to his bed, sat down, and facing the tester, would not charge again. Unlike his behavior following the Skunker tests, he did not seem restless or inclined to leave the area when the tester had retreated. In less than 30 minutes, he appeared to be behaving normally. His behavior and appetite were not visibly affected on the following day. However, he would not charge during presentation of the next test.

In response to presentation of the air horn, Bear 1 remained aggressive throughout the test, but did not charge, as had Bear 2 (Table 1). Taped sounds of a male grizzly bear caused the bear to charge the tester and then remain aggressive during the rest of the test. Taped rock-and-roll music elicited a mixed reaction. During the instrumental section, the bear remained relatively quiet, seemingly confused and nervous. Immediately at the onset of the vocal section, he charged, then remained aggressive to the end of the test.

In response to tests of the water spray and control in the laboratory, Bear 1 always was aggressive or charged (Table 1). The difference between his response to the water spray in the laboratory and when on the snare probably reflects the negative effect the snare had on his aggressive movements.

Overall, the added negative effect of the snare on the bear's movements appeared to inhibit aggressive responses when compared to the laboratory tests. Results of the limited tests on Bears 1 and 2 indicated that the Shield, air horn, taped radio-music, and taped bear-sounds were not promising repellents, whereas the Halt and Bear Skunker appeared to have potential. During tests of Halt by Miller (1980) and this pilot test, all bears were instantly repelled, however, they seemed to recover quickly. Although the Bear Skunker did not repel bears immediately, further aggressive movements toward the tester ceased. It seemed to have a longer-lasting effect than the Halt; bears appeared restless and uncomfortable for some time following a test. One bear displayed submissive and avoidance postures a month later when confronted with the odor. The combination of an odor and pain-inducing cue addressing more than 1 sense may have contributed to the effectiveness of this stimulus. Incorporation of a highly repellent substance such as Halt with the Skunker product may produce an instantly effective, long-lasting repellent.

Bear 1 was held over winter and retested in June of 1982. During October 1981, his food intake slowed. The bear was then provided with a den and bedding material by darkening one cell and placing several bales of hay in both cells. The supplemental (electric) lighting in the laboratory was turned off, and food (<u>but not water</u>) was withheld from him from 15 December to 17 March. He appeared to hibernate normally, and was in good health when he again became active in March and feeding was resumed.

General Behavior During Baseline and Test Periods, 1982

Stimuli were tested on Bears 1, 4, 5, and 6 between 5 July and 8 August, and on Bear 7 between 1 and 15 December, 1982 (Appendix 1). Stimuli tested were controls, a quickly-opened umbrella, railroad flares, Bear Skunker, Halt, and a Skunker/Halt combination.

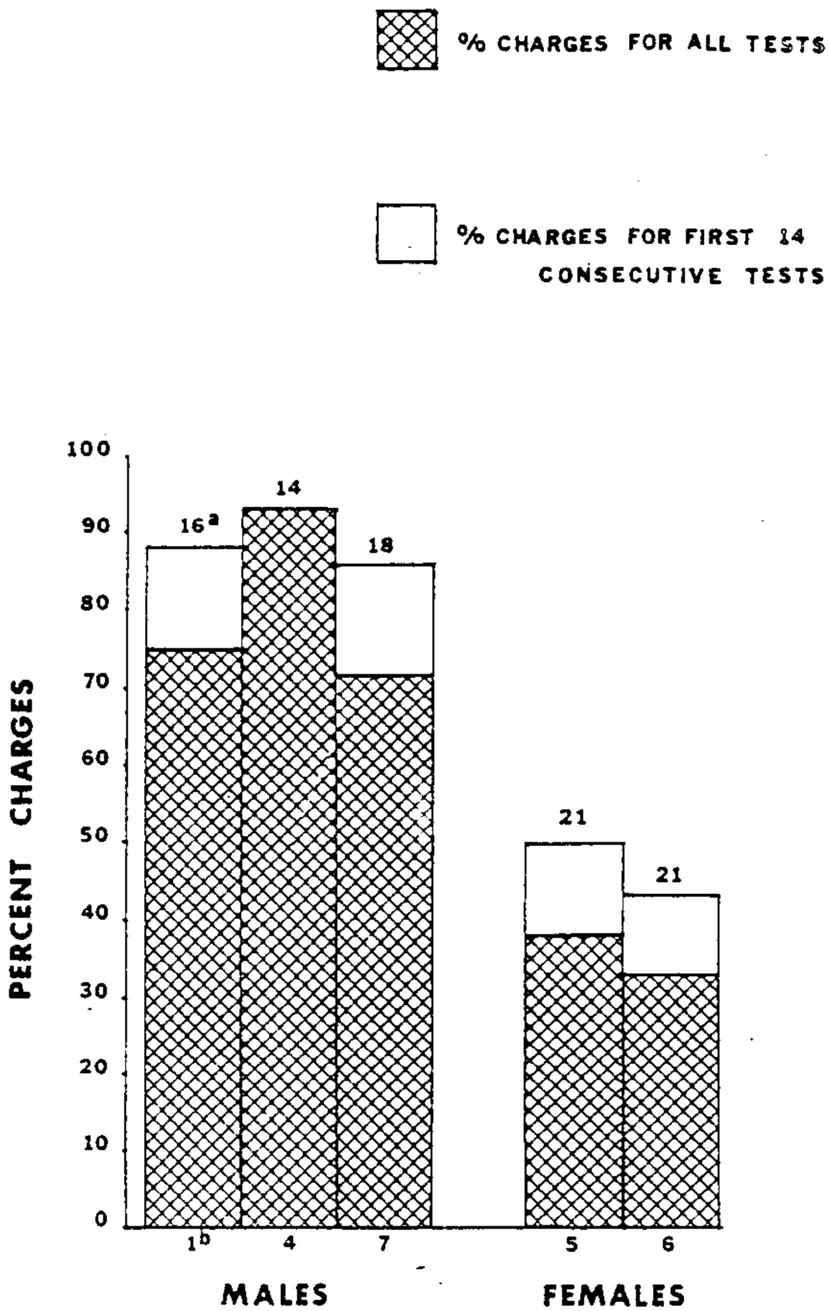
Responses to tests were influenced by the individual bear and the effectiveness of the stimulus. Behavioral characteristics observed during the baseline observation period appeared to be related to test period responses.

Bears seemed to consistently behave relatively more or less aggressively throughout baseline and test periods. The 3 males (Bears 1, 4, and 7) were consistently more aggressive than the 2 females (Bears 5 and 6). They more frequently approached, rather than avoided confrontations. During baseline observations, the males generally responded to new sounds and the proximity of the keeper with aggressive postures, charges, and vocal displays. Females usually displayed no aggression; 1 female (5) approached boldly, yet non-aggressively, while the other (6) generally remained sitting near the wall in the corner of the cell, with no movements or vocalizations. She appeared highly stressed by captivity. During tests, upon approach by the tester, male bears charged more often than females (Fig. 2). In response to the delivery of stimuli the frequencies of submissive and repel responses to specific stimuli by females were relatively higher (Fig. 3).

Of the males, Bears 1 (1982) and 7 reacted more aggressively to the proximity of humans and test stimuli than Bear 4; Bear 4 was often repelled by stimuli, such as the flare and Skunker, which did not repel the other 2 animals (Table 2). Bear 5 generally avoided aggressive confrontations with the tester; she approached new sounds, the umbrella, and control tests boldly, but avoided the flare and Skunker stimuli. Bear 6 attempted to avoid all confrontations, including those of the control tests (Table 2).

Bears that had difficulty in adapting to captivity and the proximity of humans appeared most stressed by the test periods and least capable of modifying their behavior to reduce or avoid stress during test situations. Bears 1 (1982), 5, and 7 seemed to adapt to captivity more readily than Bears 4 and 6, possibly because they were already habituated to the proximity of humans. Recorded baseline observations

Fig. 2. Incidence of charge responses by individual bears upon appearance of tester.



a = number of tests

b = bear identification number

Fig. 3. Response of charging bears following application of stimulus according to sex and stimulus used.

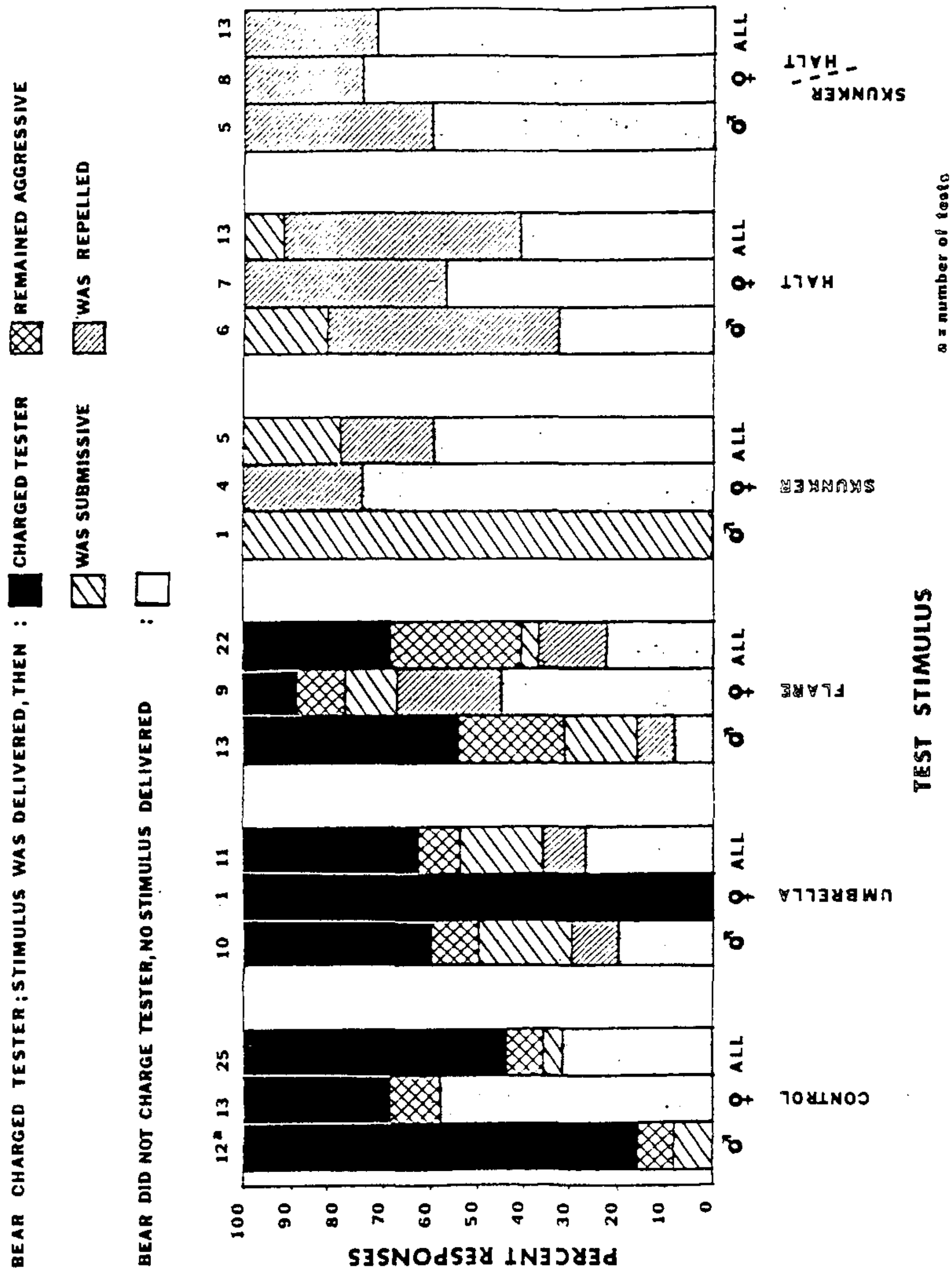

BEAR CHARGED TESTER; STIMULUS WAS DELIVERED, THEN :
CHARGED TESTER
REMAINED AGGRESSIVE
WAS SUBMISSIVE
WAS REPELLED
BEAR DID NOT CHARGE TESTER, NO STIMULUS DELIVERED :
PERCENT RESPONSES
100
90
80
70
60
50
40
30
20
10
0
12*
13
25
10
1
11
13
9
22
1
4
5
6
7
13
5
8
13
♂
♀
ALL
CONTROL
UMBRELLA
FLARE
SKUNKER
HALT
SKUNKER - HALT
TEST STIMULUS
* = number of tests

TABLE 2. Effect of test stimuli on individual bears when charging.

STIMULUS	BEAR	NUMBER OF TESTS	DID NOT CHARGE	IMMEDIATE RESPONSE TO STIMULUS			
				Repel	Submissive	Aggressive	Charge
Control	1 (1982)	4					4 (100)[a]
	4	4					4 (100)
	7	4			1 (25)	1 (25)	2 (50)
	5	4					4 (100)
	6	9	8 (90)			1 (10)	
		25					
Umbrella	1 (1982)	6	2 (34)		2 (34)		2 (34)
	4	4		1 (25)		1 (25)	2 (50)
	5	1	1 (100)				
		11					
Flare	1 (1982)	5			2 (40)	1 (20)	2 (40)
	4	4	1 (25)	1 (25)			2 (50)
	7	4				2 (50)	2 (50)
	5	4	3 (75)				1 (25)
	6	5	1 (20)	2 (40)	1 (20)	1 (20)	
		22					
Water	4	1					1 (100)
		1					
Skunker	7	1			1 (100)		
	5	4	3 (75)	1 (25)			
		5					
Halt	1 (1982)	1			1 (100)		
	4	1		1 (100)			
	7	4	2 (50)	2 (50)			
	5	4	3 (75)	1 (25)			
	6	3	1 (33)	2 (67)			
		13					
Skunker/ Halt	7	5	3 (60)	2 (40)			
	5	4	3 (75)	1 (25)			
	6	4	4 (100)				
		13					
		90					

[a] (Percent).

of overall activities and body positions for bears indicated that Bears 1 (1982) and 5 spent more time quietly lying on their sides than all other bears. Bears 1 (1981), 4, 7, and 6 were more frequently involved in light and moderate activities (Tables 3a and 3b). Bear 5 generally appeared relaxed and primarily interested in eating. Bears 1 (1982) and 7 seemed calm but alert at most times; Bear 1 had been much more restless in 1981. Bears 4 and 6 appeared most stressed by captivity, often exhibiting restlessness and displacement activities.

During test periods, bears generally spent more time quietly lying on their bellies or sitting, and less time lying on their sides or involved in eating, drinking, or light and moderate activities (Tables 3a and 3b). These changes were primarily related to post-test observations and reflect tension and alertness associated with the effect of the tests on each bear.

Changes were most substantial for Bears 4, 6, and 7. Bear 4 remained nervous throughout the test period, exhibiting light and moderate overall activities with increased frequency (Table 3a). These reflected an increase in displacement activities. Changes in body positions were most substantial for Bears 6 and 7 which spent more time sitting or standing, suggesting increased alertness or tension (Table 3b).

TABLE 3a. Comparison of overall activities for each bear during baseline and test periods.

PERIOD	BEAR	NUMBER OF OBSERVATIONS	OVERALL ACTIVITY (%)					
			Sleep/ quiet	Elimination	Eat or drink	Light activity	Moderate activity	Heavy activity
Baseline	1 (1981)	1872	(84)	(4)	(11)	(1)		
	1 (1982)	487	(94)		(5)	(1)		
	4	485	(77)		(10)	(13)	(1)	
	7	444	(88)			(9)	(2)	(1)
	5	466	(86)		(6)	(4)	(3)	
	6	353	(98)			(2)		
	Total	4007	(86)		(4)	(8)	(1)	
Test	1 (1981)	867	(95)		(1)	(4)		
	1 (1982)	833	(97)			(4)		
	4	838	(88)		(3)	(6)		(2)
	7	977	(87)			(9)	(3)	(1)
	5	1303	(83)		(9)	(6)	(1)	
	6	1321	(98)			(2)		
Total		6139	(91)		(3)	(5)	(1)	(1)

TABLE 3b. Comparison of gross body positions for each bear during baseline and test periods.

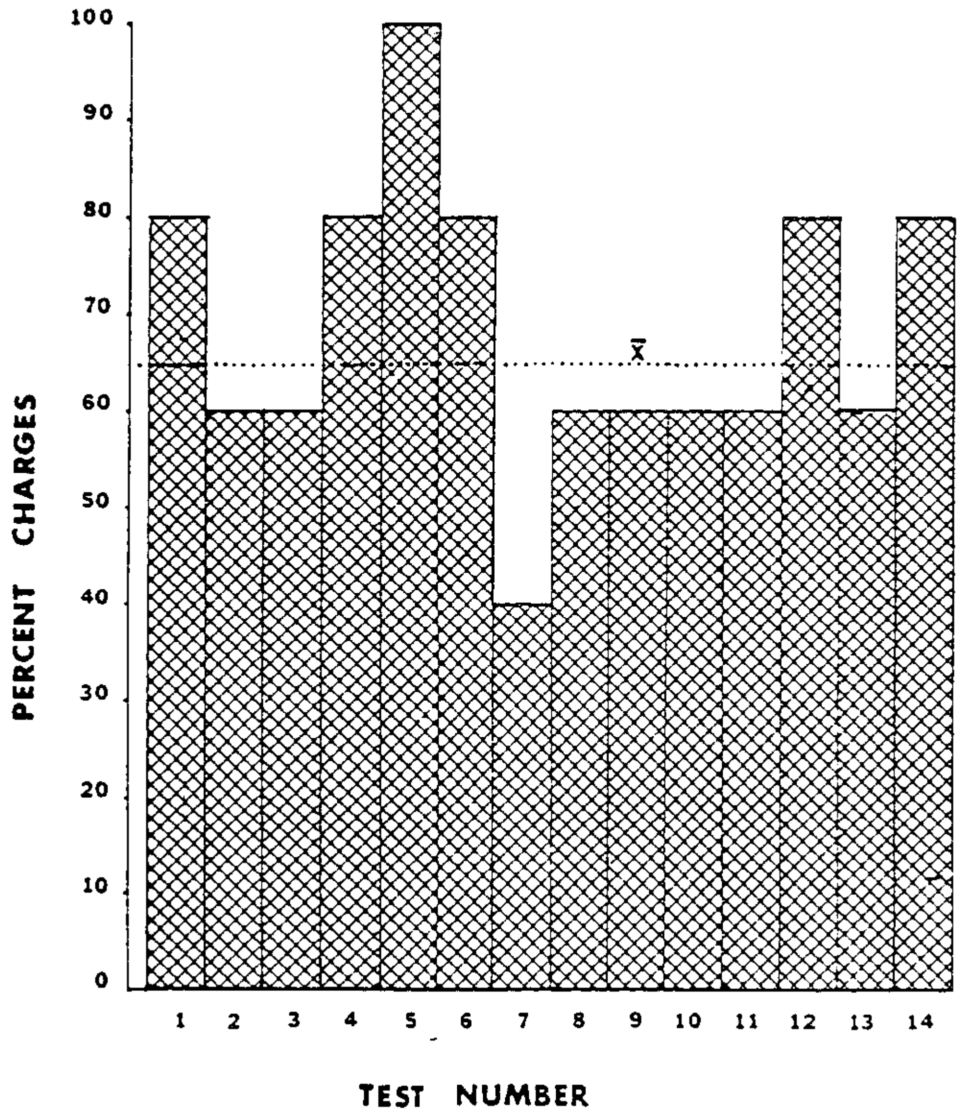
PERIOD	BEAR	NUMBER OF OBSERVATIONS	GROSS BODY POSITION (%)						
			Lying on side	Lying on back	Lying on belly	Sitting	Sitting/ crouched, hunched	Standing	Pullup at door
Baseline	1 (1981)	1872	(47)	(1)	(28)	(12)		(9)	(3)
	1 (1982)	487	(65)		(26)	(8)		(1)	
	4	472	(42)	(22)	(12)	(4)	(3)	(15)	(2)
	7	444	(55)		(34)	(2)	(2)	(7)	
	5	366	(60)	(8)	(22)	(4)		(6)	
	6	353	(37)	(6)	(43)	(8)	(4)	(2)	
	Total	3994	(50)	(4)	(27)	(8)	(1)	(8)	(2)
Test	1 (1981)	867	(36)		(4)	(12)		(9)	(3)
	1 (1982)	833	(62)	(1)	(24)	(10)	(1)	(2)	
	4	838	(38)	(22)	(27)	(3)	(2)	(8)	
	7	975	(17)		(61)	(11)	(3)	(8)	
	5	1303	(48)	(3)	(33)	(9)		(7)	
	6	1321	(9)		(32)	(55)		(4)	
	Total	6137	(33)	(4)	(36)	(19)	(1)	(6)	(1)

Only Bears 5 and 7 appeared to modify their behavior to avoid application of stimuli. However, Bears 5, 6, and 7 were the only bears presented with a series of highly repellent stimuli. Following the first few repellent trials, Bear 5 attempted to avoid application of stimuli by leaving the room during the pre-test periods; leaving the room or backing away from the tester with no aggressive signals when closely approached, or lying without movement and ignoring the tester during a test. Following the first 2 Halt tests, Bear 7 also began to exhibit these behaviors. After the first few Halt tests Bear 6 began to spend more time in the alternate room, however, this bear seemed unable to refrain from charging the tester when approached closely, even when repelled in the preceding test.

Responses to Test Stimuli, 1982

All bears were presented with at least 14 tests. Bears 1 and 4 were tested with identical stimuli, and Bears 5, 6, and 7 were tested with similar but not identical stimuli (Appendix 7). Throughout the tests, bears continued to charge upon the appearance of the tester approximately 66% of the time, indicating that responses to the tester were not influenced by the number of tests delivered to each bear (Fig. 4).

Fig. 4. Incidence of charge responses by all bears upon appearance of the tester during first 14 consecutive tests (N = 90).


100
90
80
70
60
50
40
30
20
10
0
PERCENT CHARGES
X̄
1
2
3
4
5
6
7
8
9
10
11
12
13
14
TEST NUMBER

Bears that charged and were then presented with a control, umbrella, or flare responded immediately by becoming aggressive or charging during 94%, 63% and 65% of the tests, respectively (Fig. 3). Proportionately, the umbrella induced more charge responses and the flare, more repel responses. In response to application of the Skunker/Halt, Halt or Skunker, no bears charged or were aggressive. Bears were repelled during 100%, 86% and 50% of the tests (Fig. 3).

Following the first application of the stimulus, as the tester continued to provoke the bear, bears that had been repelled or submissive immediately, remained so during approximately 90% of the tests, and 92% of those that had charged upon the delivery of the stimulus recharged the tester (Table 4a).

Bears frequently recharged or remained aggressive after having been presented with a control, umbrella, or flare test. Aggressive and recharge responses were much lower to the Halt (15%), Skunker/Halt (8%), and Skunker (0%; Table 4b).

Generally, all bears except Bear 6 charged and then recharged in response to presentation of the control tests (Table 2). Bears seemed to become more inclined to charge with each repetition of the test.

TABLE 4a. Relationship of all bears' immediate response to stimulus with their continued response to provocation following delivery of stimulus.

IMMEDIATE RESPONSE TO STIMULUS	NUMBER OF TESTS	CONTINUED RESPONSE TO TEST	
		Repel/Submissive	Aggressive/Charge
Repel	14	13 (93)[a]	1 (7)
Submissive	8	7 (88)	1 (12)
Aggressive	7	3 (43)	4 (57)
Charge	26	2 (8)	24 (92)

TABLE 4b. Continued response of all bears according to stimulus.

STIMULUS	NUMBER OF TESTS	CONTINUED RESPONSE TO TEST	
		Repel/Submissive	Aggressive/Charge
Control	25	10 (40)	15 (60)
Umbrella	11	6 (55)	5 (45)
Flare	22	13 (59)	9 (41)
Water	1		1 (100)
Skunker	5	5 (100)	
Halt	13	11 (85)	2 (15)
Skunker/Halt	13	12 (92)	1 (8)

[a] (Percent).

The lower proportion of charge responses, and the higher frequency of repel responses to the quickly opened umbrella (Fig. 3), suggest that the stimulus was more effective than the control, but generally not effective enough to repel even less aggressive bears (Table 2). During continued provocation, Bears 4 and 5 recharged and then displayed curiosity about the tester's presence behind the open umbrella, attempting to look around it. Having initially charged the stimulus, Bear 1 then appeared to ignore it.

The flare elicited less immediate charges and more immediate repel responses than the umbrella (Fig. 3), and a higher percentage of bears that were not repelled immediately were subsequently repelled during continued provocation by the tester. However, it also produced more immediate aggressive responses than the umbrella, and during continued provocation by the tester, more bears recharged the flare than the umbrella.

It appeared that bears that had consistently been aggressive (males) frequently charged the flare, while consistently non-aggressive bears (females) were more often repelled or submissive (Fig. 3). Of the males, Bear 7 always responded by charging or with aggression; Bear 1 reacted with more charge and aggressive responses than did Bear 4. Bear 4 was repelled more often by this stimulus than Bear 1 or 7. Bear 5 (female) responded with a charge during the first test, then never charged again. Bear 6 (female) responded aggressively only during the first test (Table 2). When first presented with the lit flare, all bears flinched or backed up slightly, and then invariably poked their noses into the smoke toward the flame, generally to within 20cm of the stimulus. This inspection lasted from 1 to almost 30 seconds.

When sprayed with Halt, bears generally turned, ran a short distance, then paused briefly to rub their eyes with their paws; then with the exception of the 2 following cases, they ran to the adjoining room or to their bed and remained there throughout the tester's continued provocation.

In all but 1 test, bears were immediately repelled by the Halt. The exception was a submissive response by Bear 1. When sprayed, the bear immediately backed into his bed, and then remained facing the tester at approximately a 30 degree angle. After 30 seconds, as the tester turned to leave, the bear recharged. Upon reapplication of the stimulus he turned and ran immediately from the room.

The first test response to Halt by Bear 7, the grizzly, deviated notably from those of other bears. When initially sprayed, the bear immediately turned and ran toward the alternate room, then hesitating before the door. he turned and recharged. Upon reapplication of the stimulus, the bear again turned and ran toward the other room, paused as he had the first time, then turned and ran to his bed, recharging 5 seconds later. This time, while being sprayed he remained standing bipedally against the door for 3 seconds, swinging his head from side to side and growling loudly, then turned and bounded from the room. For the next 2 minutes he could be heard moaning loudly, and moving his bedding around. By the next day he had moved all the straw and his bed from the test room into the alternate room and was lying on a new bed. During subsequent tests, when initially sprayed, he turned and ran immediately from the room. During the first test the bear's initial responses to application of the stimulus were to turn and run immediately; I believe that the recharges occurred because the bear perceived no option for escaping the situation.

Reactions of Bears 5 and 7 to Bear Skunker were similar to those of Bears 1 and 2 in 1981. The less aggressive Bear 5 was initially reluctant to charge at all, probably as a result of the stimulus odor. When a charge was elicited and the stimulus presented, she was immediately repelled. Throughout the remaining Skunker tests, she would not charge the tester. Bear 7 responded to 1 test of Skunker with an immediate reduction in aggressive activity, and vocalizations and would not charge again (Tables 2 and 4b). When next confronted by the odor he would not charge.

Initial reactions by bears to the tester with Skunker/Halt were similar to those of bears to Skunker. Less aggressive bears were reluctant to charge during the first test. Once sprayed, all bears immediately turned and ran from the room. During continued provocation, bears would not recharge (Table 2), although one bear did assume an aggressive stance (Table 4b). In subsequent Skunker/Halt tests, Bear 5 did not charge again, and Bear 7 did not charge during the next 2 tests.

When bears had charged or been aggressive in response to the previous stimulus, they charged upon appearance of the tester during the next test, 94% of the time. However, bears that had been repelled (n=12) during the previous test charged only 42% of the time (Fig. 5).

Bears generally charged the tester if the previous test delivered was a control, flare, or umbrella (Fig. 6). If the previous test had been with Halt, Skunker, or Skunker/Halt combination, bears charged 40%, 0%, and 0% of the time.

Latency to charge was also influenced by the previous test response; bears appeared to learn from and remember test encounters. When bears charged immediately upon the appearance of the tester, 87% of the time they had been aggressive or charged in response to the preceding test stimulus (Table 5). None of the bears charged immediately if they had been repelled during the previous test. Of the bears that did not charge during a test, 80% had been submissive or repelled during the previous test.

General Relationships of Temperament and Stimulus Effect to Bear Behavior

Differences in temperament between bears were indicated by

Fig. 5. Response of individual bears to the appearance of the tester in relation to the previous test response.

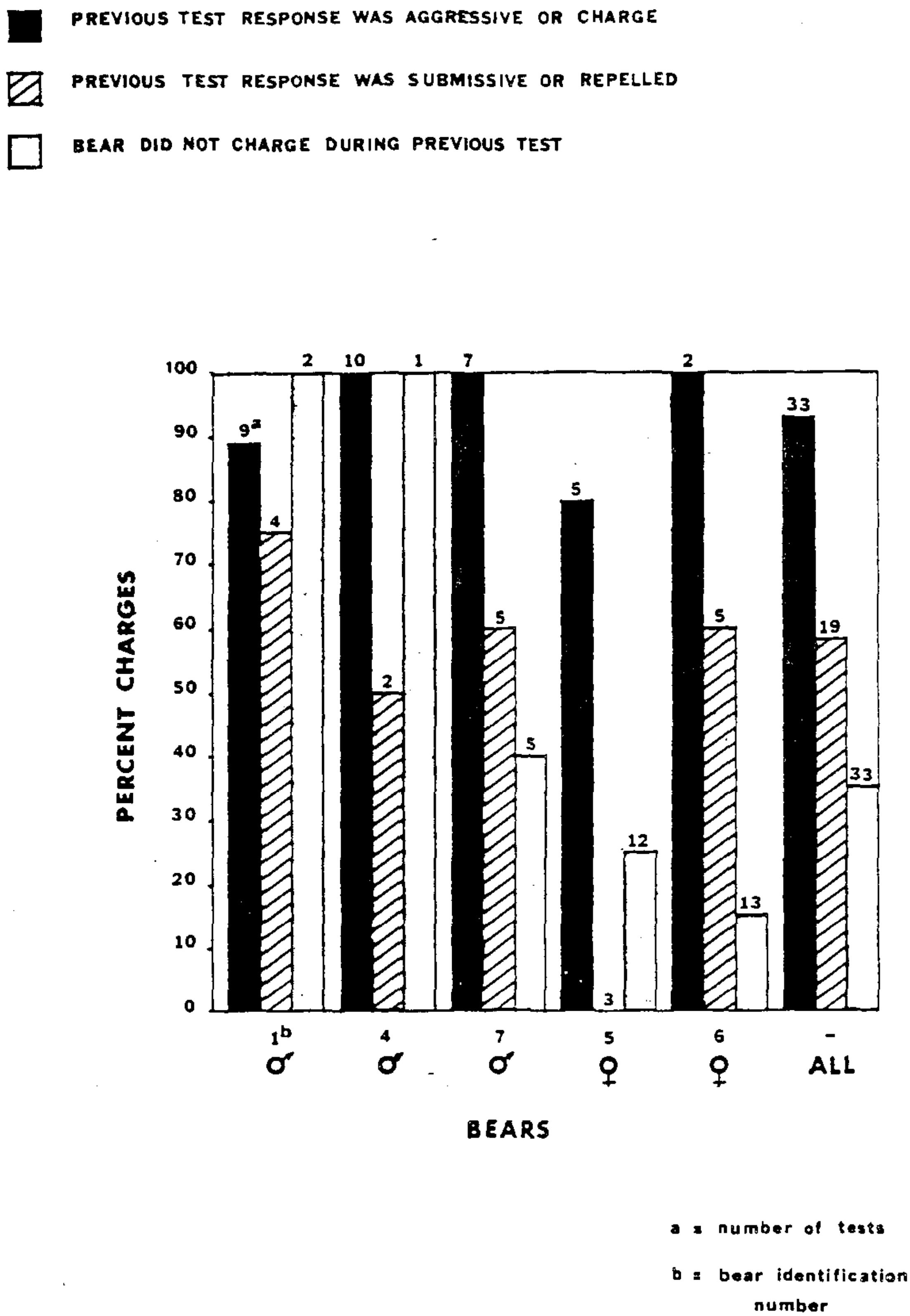
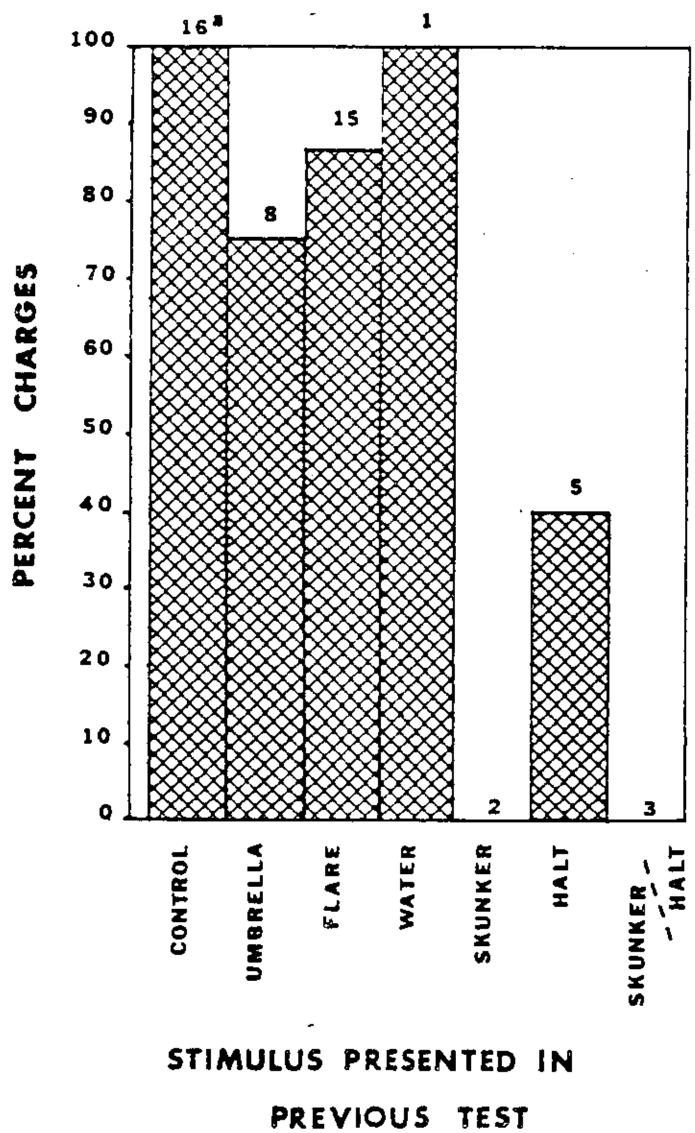

PREVIOUS TEST RESPONSE WAS AGGRESSIVE OR CHARGE
PREVIOUS TEST RESPONSE WAS SUBMISSIVE OR REPELLED
BEAR DID NOT CHARGE DURING PREVIOUS TEST
PERCENT CHARGES
100
90
80
70
60
50
40
30
20
10
0
9a
4
2
10
2
1
7
5
5
5
3
12
2
5
13
33
19
33
1b
4
7
5
6
-
ALL
BEARS
a = number of tests
b = bear identification number

Fig. 6. Response of all bears to the appearance of the tester in relation to the previous test stimulus. Does not include 35 tests where bears did not charge during the previous test.



a = number of tests

TABLE 5. Latency to charge in relation to submissive or aggressive behavior during the previous test. Does not include 30 tests where bears did not charge during the previous test.

TIME TO FIRST CHARGE (SECONDS)	NUMBER OF TESTS	PREVIOUS TEST RESPONSE	
		Repel/Submissive	Aggressive/Charge
0 (Immediate charge)	16	2 (13)[a]	14 (87)
1	10	1 (10)	9 (90)
2	2	1 (50)	1 (50)
5	2		2 (100)
6	10	1 (10)	9 (90)
7	10		10 (100)
8	2	1 (50)	1 (50)
10	3	2 (67)	1 (33)
15	5		5 (100)
20	10		10 (100)
25	9		9 (100)
30	1		1 (100)
35	2		2 (100)
45	2	1 (50)	1 (50)
50	10	1 (10)	9 (90)
55	1		1 (100)
88 (No charge)	10	8 (80)	2 (20)
	52		

[a](Percent).

variations in their initial responses to captivity and human proximity, changes in their behavior during testing, and the strength and characteristics of their responses. Baseline observations of each bear's behavior appeared to provide a general profile of each animal's temperament that was related to the overall test period behaviors. Certain bears were consistently more aggressive than others. The data suggest that these bears may be less easily repelled than others. Overall, bears that appeared to have difficulty adjusting to captivity and human proximity during baseline observations appeared most stressed by tests and less flexible or slower in adapting their behavior to reduce stress during test situations. Observations of responses by bears that had been habituated to people suggested that they adjusted quickly to captivity, and they responded to repellent cues by modifying their behavior both before and during tests to avoid confrontations. These data suggest that certain bears may be more capable of adapting to human-linked situations than others, and that these bears may be most capable of modifying their behavior to co-exist with humans.

Behavioral parallels to the above were observed during studies of black bears in the Smokies (Eager and Pelton 1979). Some bears were consistently more aggressive than others toward humans. Although bears generally exhibited restraint when interacting with humans in situations that could have led to aggressive contact, certain bears were more flexible in tolerating the proximity of humans and other factors involved in panhandling situations. These factors appeared to influence the decision each bear made as to whether it was going to panhandle and to what extent.

Certain stimuli were effective in repelling all bears. Individual differences in temperament among the bears were more important in determining the responses to less effective stimuli; although reactions were variable, responses by individual bears were generally predictable.

Whether or not a bear charged during a test appeared to be determined by its previous test response. All bears that responded aggressively or charged when a stimulus was presented, subsequently displayed a high tendency to charge both in response to the tester's continued provocation and in the following test when initially approached by the tester. During the following test, the frequency of immediate charges in response to the approach of the tester also increased. During repetitions of the control tests, bears received no punishment when charging, and all bears rapidly became more bold or aggressive in their approaches.

Similarly, bears tended to avoid further confrontations if they had been submissive or repelled during presentation of the stimulus. When the stimulus was highly effective such as in Halt and Skunker/Halt tests, the number of times that bears did not charge again during continued provocation and in subsequent tests increased. The addition of an odor cue such as that provided by the skunk mercaptan seemed to increase the stimulus effectiveness. During tests, Skunker alone was not immediately repellent, but it was discomforting. In subsequent tests the odor cue appeared to reduce the frequency of charges upon the appearance of the tester. Less aggressive bears were reluctant to charge when first confronted with the odor.

When the stimulus was not highly effective, yet frightening and perhaps harder to ignore, (such as during the flare tests as compared to the umbrella tests), aggressive bears seemed to charge again more frequently, while submissive bears were repelled or submissive more often. This may explain why reports vary on the effectiveness of certain devices or methods for repelling bears.

Dominance between individual bears has been reported to be settled during the first few encounters, and thereafter maintained primarily through visual signals (Hornocker 1962, Herrero 1980). The apparent speed with which the bears adjusted their behaviors relative to the effectiveness of the test stimuli, suggested that their responses may have been mediated by the same behavioral mechanisms active in the establishment and maintenance of dominance hierarchies between bears. The immediate effectiveness of the Halt, Skunker and Skunker/Halt in reducing charges, both during and in subsequent tests, may reflect the ease with which effective repellents, combined with additional auditory, olfactory, or visual signals can modify bear response patterns during and in subsequent bear-human encounters.

Bear-Human Communication

Throughout the tests bears appeared to signal their submissive or aggressive intentions by displaying specific, repeated head movements, eye contact, and by positioning of their torsos relative to the tester. In communicating a reluctance to charge, the bears often assumed a seated or crouched posture, with their torsos at an angle to the tester. The head was held below shoulder level and swung slowly in an arc from 1 side to the other, generally with a 1 to 3 second hesitation at each side where the profile was presented to the tester. The nose pointed down at about a 30 degree angle, and little prolonged eye-contact with the tester was made. The mouth-open-close, and tongue extension behaviors reported by Eager and Pelton (1979) often occurred in conjunction with these movements.

A mounting tendency to charge was accompanied by increasing the speed of the side-to-side head swing, while decreasing the amount of time spent presenting the head profile. The head and nose were raised slightly. Bears hesitated more often and for longer periods at mid-swing, eyeing the tester directly. Slight shifting of the shoulders and torso toward the tester, lifting of a front paw, or a tensing of the hindquarters were often observed in conjunction with these changes.

During tests in 1982, when a bear did not charge, the initial angle of its torso to the tester was greater than 30 degrees, usually greater than 45 degrees, 83% of the time (Table 6a). When a bear did charge, its angle to the tester was less than 30 degrees 44% of the time. Following application of a stimulus, 83% of the times that bears did not recharge their bodies were positioned at an angle greater than 30 degrees to the tester (again, generally greater than 45 degrees). When bears had positioned themselves at angles less than 30 degrees, they recharged the stimulus 66% of the time (Table 6b).

An increase in the frequency of certain activities was associated with the post-test periods and appeared to reflect stress caused by the test experience. These stress related activities included: yawning; tongue extensions; licking, biting and chewing on toes, claws, and pads; "moan" vocalizations; curling of paws and toes while lying down; scratching; and playing with food or straw.

Similar movements by the tester seemed to bring about predictable responses from bears. The tester provoked all bears to charge, except the non-aggressive Bear 6, by standing upright and facing them, while making direct eye contact and rhythmically stomping the ground with 1 foot. Often, as the tester ceased stomping and turned to leave, the male bears responded by lurching forward aggressively or charging.

TABLE 6a. Relationship of the angle of the bear's torso to the occurrence of charges during initial responses to the tester, prior to delivery of stimuli.

INITIAL RESPONSE TO TESTER	NUMBER OF TESTS	DEGREE ANGLE TO TESTER				
		0	≤ 30	≤ 60	≤ 90	+ 90
Did not charge	35	4 (11)[a]	2 (6)	6 (17)	12 (34)	11 (32)
Charged	55	12 (22)	12 (22)	12 (22)	11 (20)	8 (14)
	90					

TABLE 6b. Relationship of the angle of the bear's torso to the occurrence of charges during continued responses to the tester, following delivery of stimuli.

CONTINUED RESPONSE TO TESTER	NUMBER OF TESTS	DEGREE ANGLE TO TESTER				
		0	≤ 30	≤ 60	≤ 90	+ 90
Repel/Submissive	56	7 (12)	5 (9)	9 (16)	11 (20)	24 (43)
Aggressive/Charge	34	16 (47)	9 (26)	4 (12)	3 (9)	2 (6)
	90					

[a] (Percent).

Attempts to provoke Bear 6 to charge by stomping failed during the first 4 tests. On the fifth test she charged almost immediately when the tester assumed a crouching position, presenting his body sideways and turning his head toward and away from her, quickly averting his eyes and turning his head when eye contact was made. Thereafter, during tests, the bear was provoked in this manner.

This same "submissive" stance also elicited approaches from other bears. It was the first and 1 of very few positions that appeared to allow Bear 1 (after the 1981 test sessions), and a grizzly bear cub (during other studies) to non-aggressively approach humans that were outside their cell door. For Bear 1, averting the eyes alone seemed insufficient to allow a peaceful approach; apparently the human's entire head had to be turned away.

The tester's crouching, "submissive stance" appeared to invite approaches. It elicited an aggressive approach from a threatened, generally non-aggressive bear, while soliciting peaceful approaches from unthreatened, non-aggressive cubs and a generally aggressive bear. Eager and Pelton (1979) also reported that visitors that knelt to photograph panhandling black bears were likely to be charged. These data, and interactions with bears following test periods, suggest that a standing, sideways stance combined with the above mentioned head movements may communicate peaceful intentions but not elicit an approach.

SUMMARY

The data indicate that repellents can be developed that will turn most bears during a charge. Halt and a Skunker/Halt combination repelled most bears, however, tests on a larger number of bears are necessary. These stimuli are not currently available with delivery systems that have the range and accuracy necessary for use on free-ranging bears. Effective repellents appear to reduce the frequency of immediate charges and the overall tendency to charge both during and in subsequent encounters. Additional odor or visual cues combined with these stimuli may increase their effectiveness. Certain bears are more aggressive than others; these bears may be less easily repelled during an encounter. Moderately effective stimuli may increase aggression in more aggressive bears, while decreasing aggression in more submissive bears. Unpunished charges appear to elicit increases in the frequency of aggression in all bears, both during and in subsequent encounters. Certain bears appear more capable of adapting to human-linked situations than others. Effective repellent combinations appear well-suited for bears already habituated to humans; these bears may react from a less basic "fight or flight" level, allowing more time during a human-bear encounter for behavioral modification. Bears communicate their aggressive intentions by displaying visual body signals involving torso positioning, head movements, and eye contact. Similar signals displayed by humans appear to elicit specific responses in bears.

PART II

AVERSIVE CONDITIONING OF BEARS TO BE RELOCATED

In North America, the most widely used methods for control of nuisance bears are to destroy the animals or to relocate them to areas where they presumably will not cause further problems. These methods are expensive, time consuming, and ineffective as long-term solutions to most bear-human problems (Herrero 1976, Jorgensen et al. 1978, Eager and Pelton 1979).

Return rates from relocations are high because bears have the ability to home (Craighead and Craighead 1972, Beeman and Pelton 1976, Alt et al. 1977, Thier and Sizemore 1981, Miller and Ballard 1982). The fate of those that do not return is largely unknown; accumulating evidence suggests that many die because of increased vulnerability associated with increased movement (post-relocation), unfamiliarity with the terrain, and non-territorial status (Jorgensen et al. 1978, Miller and Ballard 1982).

Bear populations have relatively low recruitment rates and generally occur over large areas in low densities (Craighead and Craighead 1972, Martinka 1976). The destruction of nuisance bears may become a significant mortality factor if the causes of bear-human problems are not prevented (Nagy and Russell 1978, McArthur 1979).

Generally, relocations and control kills are only treatments of the symptoms. They do not eliminate the causal factors that create nuisance bears. They do not prevent the problem from recurring, either by the same animal or another that moves in. These methods have their place, but should be used only in conjunction with management measures designed to prevent human-bear conflicts (McCabe and Kozicky 1972, Gilbert 1977, Follman et al. 1980).

Resolution of conflicts through aversive conditioning of bears has met with limited success (Gilbert and Roy 1977, Dorrance and Roy 1978, Hastings and Gilbert 1981, Greene 1982). Application to free-ranging bears is difficult because conditioning must be consistently applied until the undesirable behavior is extinguished. Certain problems, and perhaps certain bears, do not lend themselves to successful aversive conditioning programs. Greene (1982) explored the possibility of capturing problem bears to condition them in captivity, and then releasing them back into the wild. A black bear (*Ursus americanus*) that had frequented a recreation area was caught in a culvert trap and classically conditioned using ultrasonic sound. Only 1 post-release trial was conducted, during which the bear was successfully repelled from the area when the ultrasonic sound was presented.

During tests of repellents on captive bears in another phase of this research (problem bears destined to be destroyed), 2 black bears and 2 grizzly bear cubs (U. arctos) were subjected to a brief series of repellent tests and then released into the wild. The goal of the tests was to cause the bears to avoid humans and their properties by conditioning them to fear human proximity.

METHODS AND MATERIALS

Test procedures and stimuli varied for each case. Generally, a "tester" confronted each bear and attempted to provoke an approach by the animal, at which time a stimulus was delivered. Bears were judged to have been repelled when they presented their torso to the tester at an angle greater than 45 degrees and made no aggressive movements toward the tester. An effort was made to avoid overconditioning; the test program ended shortly after any approach of the animal elicited a repellent response. Tests were aimed at conditioning the bear to associate the stimulus effect with their approach or aggression toward the tester; overconditioning could cause an association of the stimulus with an unavoidable test situation, or produce undesirable behaviors toward humans.

Bear 2, an adult black bear and chronic campground nuisance, was tested while restrained by an Aldrich Leg-hold Snare anchored to a tree with a 4m cable lead. Tests were run 1 hour apart and the bear was provoked into aggression by a tester standing and directly facing the bear while stomping a foot.

Bear 3, a yearling black bear, and Bears 81 and 82, sibling grizzly bear cubs, were orphans that had been conditioned to receiving food from humans. These bears were held in captivity for several months and fattened, then tested in a laboratory (Figure 1). Tests were run 10 hours apart and presented quietly, with no provocation other than the continued presence of the tester.

All bears were held in isolation from human activity, and direct visual contact with humans was prohibited except during tests. Bears were presented with a control test, where the tester presented himself, but delivered no stimulus when approached, and then with 1 or 2 repellent tests, depending on the responses of the animal. All animals were tattooed, ear-tagged, and released within 24 hours of their last test.

RESULTS

On 6 July, 1981, Bear 2 was presented with 1 test each of the waterspray, air horn, and Bear Skunker stimuli (Appendix 2). Throughout the tests, the bear was reluctant to demonstrate aggression; most of his activities reflected attempts to avoid confrontations and to escape the snare.

When finally provoked into aggression and sprayed with water, the bear flinched, and then resumed his efforts to escape. In response to the air horn, the animal charged the tester again. Bear Skunker was delivered last; the bear immediately ceased all aggressive movements and became more active in his efforts to escape the snare than he had been previously. When reapproached, he could not be provoked into aggressive activity or even to get up from where he lay. He behaved in a subdued manner, making no vocalizations and repeatedly turning his head away from the tester.

Bear 3 was held from mid-January through 10 June, 1982. During 8 and 9 June she was presented with a control, water spray, and 2 Halt tests. Throughout the tests she would not approach or charge the tester. During the first control and the following Halt test she displayed aggression, standing, hissing, and eyeing the tester directly with little side to side head movement. When sprayed in this stance with Halt, she immediately ran from the room. During the subsequent water and Halt tests she displayed no aggressive movements. She did not vocalize, and remained lying down with her torso at an angle of greater than 45 degrees to the tester, with no movement other than a slow turning of her head from side to side. She was sprayed during both tests, upon which she immediately ran from the room.

Bears 81 and 82 were held from 25 August to 30 November, 1982. Simulated denning cues induced the cubs to den approximately 1 week prior to testing. During 28 and 29 November they were presented with 1 control, 1 foot stomp, and 1 Halt test. Throughout the tests the cubs generally remained huddled in the far corner of their cell, torsos at 60 to 90 degree angles to the tester, turning their heads slowly from side to side, making little eye contact with the tester, and periodically moaning softly.

Neither bear approached during the first (control) test. Bear 82 made a non-aggressive approach during the second test, shortly after the tester had crouched and presented his body sideways to the bears, while turning his head and eyes toward and away from them. At this time the foot stomp was delivered, and the cub immediately ran back to its sibling. During the following Halt test neither bear would approach. When Bear 81 finally got up, apparently to leave the room, she instead turned back toward her sibling, then turned and faced the tester. Both bears were thereupon sprayed with Halt. Their response was a blind panic; they ran about, bumping into each other, trying to huddle behind one another, attempting to climb the cell walls, all the while crying loudly. They did not enter the adjoining room. After the first minute, the tester went to the far end of the facility and sat quietly through the end of the observation period. The cubs began to quiet down after 6 minutes, and finally became silent 21 minutes after the test. Due to the strength of their response, and because they were unlikely to approach again and did not seem to perceive the adjoining room as an option for escape, no subsequent tests were conducted.

Following the tests the cubs were fitted with expanding radio collars, and transported to an artificial den at a release site. They remained in the den until May. A follow-up monitoring and aversive conditioning program was planned for the 1983 season, but both cubs slipped their collars shortly after emerging from the den. Efforts to capture and recollar them failed.

The fate of these bears after their release is unknown. However, since their release none of the 4 bears is known to have caused trouble or been reported in the hunter harvest (K. Alt 1983 pers. comm., R. Klaver 1983 pers. comm.). With the exception of 2 sightings of the grizzly cubs by a hunter early in the spring of 1983, the bears have not been seen since their release.

An aversive conditioning program similar to the above laboratory programs has recently been applied to a 5 year old, male grizzly bear. Following the tests, the bear was fitted with a radio-collar and transported to a man-made den in the wild, in which he remains at this writing. The bear will be monitored and aversively conditioned if necessary during the 1984 season.

DISCUSSION

Bears communicated their aggressive or submissive intent by torso positions, head movements, and eye contact, similar to those displayed by bears during other portions of the project. The stomping activity by the tester produced aggressive responses by the adult black bear as observed during tests of most other bears. It produced a repellent response in the non-aggressive cubs similar to the effect it had had on a non-aggressive adult black bear. The submissive stance assumed by the tester when confronting the cubs elicited an approach, as it had during tests of 2 other black bears.

Although the sample size is small, the data suggest that aversive conditioning of captive bears may be an effective method for initial conditioning of certain problem animals from approaching humans once released into the wild. Factors that were probably important in the apparently successful conditioning and release of these bears were: a) bears were isolated from visual contact with humans except during tests; b) overconditioning during tests was carefully avoided; c) the timing of each bear's release; and d) the non-aggressive temperament of all 4 bears.

The goal of the tests was to condition bears against approaching humans and to cause them to react to human proximity by fleeing. It was hoped that bears would transfer this aversion to human properties. During tests it was important that bears associate their actions (e.g.

an approach, aggression, or retreat) with whether or not a stimulus was delivered. Over-conditioning, subjecting bears to too many tests in the laboratory, may prevent bears from making the necessary associations regarding their activities and encounters with humans. Overconditioning could cause bears to associate humans and the effects of the stimulus with an unavoidable situation, and/or cause bears to be less flexible in modifying their behavior to avoid interactions with humans. Depending on the bear, undesirable behaviors towards humans could result subsequent to their release.

The timing of each bear's release probably enhanced the program's chances of success by reducing the potential for bear-human conflicts. The yearling and cubs were fattened and then released during seasons when their post-release movements would be minimized; their motivation to locate familiar food sources (or denning areas) was reduced, and accumulations of snow further restricted their movements. For the cubs, induced hibernation and placement in an artificial den upon release, reduced post-release movements and extended the period during which bears could dis-habituate (Jope 1982) to humans.

The non-aggressive temperament of all the bears may have been the key factor in the success of this program. This may be a factor critical to the success of any aversive conditioning program. During this study and other phases of the project, certain bears were consistently less aggressive than others, both during baseline and test observations. Non-aggressive bears were generally easily distinguished during baseline observations. They were inclined to avoid aggressive confrontations with humans and were repelled easily during tests, even when confronted with only somewhat effective repellents. Such bears were determined to be likely candidates for successful aversive conditioning and subsequent release. Once released, non-aggressive bears may be most likely to avoid people, least likely to cause further trouble, and more easily conditioned should further aversive conditioning be necessary. The relationship of pre-test laboratory observations of bears with their test responses, may provide a basis for evaluating the suitability of specific valuable bears (e.g. reproductive-age females) for aversive conditioning programs either in captivity or in the wild.

PART III

TESTS OF REPELLENTS AND DETERRENTS ON FREE-RANGING BEARS AT A DUMP

Increasing numbers of bear-human conflicts have been reported in many areas where the activities of humans and bears overlap. Most commonly, conflicts involve property damage (Mundy and Flook 1973, Jonkel 1975, Herrero 1976, Schweinsburg 1976, Singer and Bratton 1980). Approaches to solutions for bear-human conflicts should revolve around preventive measures that preclude the establishment of behaviors that lead to conflicts, and that are based on predictable behavioral and ecological relationships.

Bears are highly mobile, opportunistic omnivores, adapted to exploit the seasonal productivity of their environment (Herrero 1976, McArthur 1979). They undergo a long period of dormancy and are thereby motivated to obtain foods high in starches, sugars, proteins, and fats, in excess of their maintenance requirements (Stebler 1972, Bacon 1973, Mealey 1975). As a result, they possess extremely adaptable behavioral mechanisms that allow them to interact advantageously with changes in their environment (Hornocker 1962, Craighead and Craighead 1972, Egbert and Stokes 1976, McArthur 1979, Eager and Pelton 1979). They are intelligent; their ability to learn has been documented by Burghardt and Burghardt (1972), Bacon (1973, 1979), and Jonkel and Cowan (1971).

They are able to remember rich food sources from year to year (Egbert and Stokes 1976, Gilbert 1977, Merrill 1978), and they are capable of learning from a single experience (Gilbert 1977).

Bear distribution is altered by their attraction to food sources made available by people (Barnes and Bray 1967, Shaffer 1968, Cole 1972, Hastings 1982). Bears appear to quickly learn to associate humans with food, and become bold in their searching for and acquisition of it. McArthur (1980) hypothesized that their behavioral plasticity, together with their opportunistic food habits, is the mechanism by which bears overcome their reluctance to forage near people.

The majority of human-bear problems stem from situations where bears have been fed or are using human food sources such as garbage or bee yards, and/or natural foods are in low abundance (Eager and Pelton 1979). In a sense, we offer bears an attractive fast-food service, high in nutritive value (Herrero 1970, Craighead and Craighead 1972, Eager and Pelton 1979). During years of reduced availability of natural foods, bears appear to rely more heavily on human foods as an alternative food resource. Interestingly, Eager and Pelton (1979) indicate that summers with numerous bear problems often precede a fall mast shortage.

Prevention of many conflicts can be achieved by excluding unwanted animals from the site or decreasing the attractiveness of the resource (Follman et al. 1980, Conover 1981). The strategy of physically preventing access to a resource has been successfully used to deter both black (Ursus americanus) and grizzly bears (U. arctos). Efforts to prevent access to human food sources by bear-proofing sites have significantly reduced conflicts in our national parks (Herrero 1976, Meagher and Phillips 1980, Hastings et al. 1981). Electric fences are widely used to prevent bear depredation of apiaries (Storer et al. 1938, Gard 1971, Hepburn 1974, Wynnk and Gunson 1977, Alt 1980); Effective designs for fences have been reviewed by Boddicker (1978) and Follman et al. (1980). Unfortunately, in many situations physical exclusion of bears may not be cost-effective or even feasible.

An alternative strategy for reducing human-bear conflicts is to modify undesirable behaviors, either by the use of fear-provoking repellent or deterrent stimuli that can reduce the bear's desire to approach a bait or enter an area, or by treating the food resource with some type of chemical repellent that reduces palatability. Both repellents and deterrents should turn bears away. Repellents are activated by humans and should immediately turn a bear away during a close approach. Deterrents should prevent undesirable behaviors by discouraging close approaches; they need not be activated by humans.

Attempts to repel bears from approaches using fear-provoking stimuli have primarily involved pain-inducing repellents. Many treatment reports are anecdotal, and only a few have been consistently applied. Most attempts have involved shooting bears with some form of projectile. Stenhouse (1982) reported 100% success using rubber bullets to repel polar bears (U. maritimus) from approaching baits, but many returned repeatedly. Reports on the effectiveness of shells loaded with birdshot or rocksalt indicate similar results (H. Werner 1983 pers. comm.).

Taste deterrents were tested on free-ranging polar bears coming to bait stations by Miller (1980). Ammonia and Pine Sol placed around baits appeared to reduce the amount of time the bears spent at them. Balloons filled with ammonium hydroxide and placed in backpacks and stuff sacks significantly decreased bear activity at campsites during a study in Yosemite National Park (Hastings et al. 1981). Tests of emetics on captive black bears and on free-ranging black and polar bears using specific baits have produced taste aversions (Colvin 1975, Wooldridge 1980). However, tests of emetics used in conjunction with an electric fence on free-ranging black bears failed to reduce damage at bee yards (Dorrance and Roy 1977). Emetics are limited in their effectiveness by the specificity of the created food aversion and by problems with dosages and field applications. Successful application of emetics during livestock, garbage or campground problems with bears is improbable (Revusky and Bedarf 1967, Hastings et al. 1981).

Gustation serves to select required nutrients and to avoid illness produced by ingested toxins, but it is suggested that because motor neurons are not involved in escaping toxicosis, space discrimination does not occur (Dorrance and Gilbert 1977). However, animals often use visual and olfactory clues to reject food after a food aversion has been established. Space discrimination occurs when pain-inducing stimuli are used, but these stimuli are limited in their effectiveness because they require consistent application until the undesirable behavior is extinguished. Bears will return unpredictably to investigate food sources that they have used in the past, making consistent treatment difficult. Deterrence of bears from certain foods, situations, or food resources in a particular space, may best be achieved by combining a taste deterrent and a pain-inducing stimulus with a constantly advertised olfactory, visual, or auditory clue.

During this study, tests were designed to distinguish effective taste and odor deterrents and pain-inducing repellents. Tests of pain-inducing repellents were of promising stimuli tested on charging bears during a laboratory phase of the project. In the future, further studies will test promising combinations of these stimuli on a larger scale.

Specifically, the objective of this study was to describe the behavioral responses of free-ranging bears to tests of pain-inducing repellents that produced promising responses in laboratory tests, and to potential repellents and deterrents not appropriately tested under laboratory conditions.

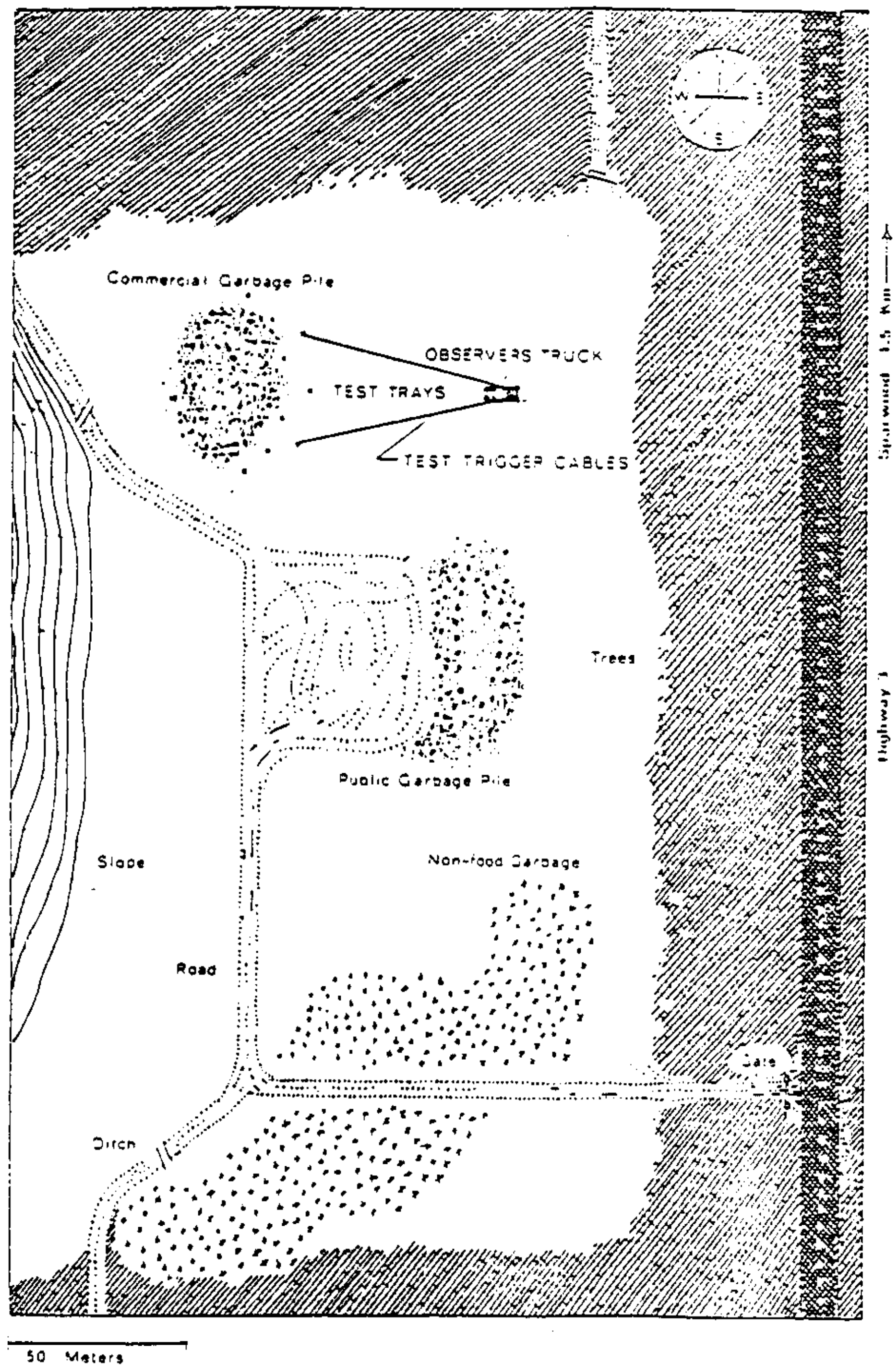
STUDY AREA

The District of Sparwood Sanitary Landfill is located 1.5km S.E. of Sparwood, British Columbia, 100m from Highway 3 (Fig. 7). Landfill operations began in 1971 and currently occupy a 300m X 200m area approximately 5m deep. An estimated 150 to 200 cubic meters of refuse is received daily. This is covered 2 to 3 times per week using a bulldozer.

The vegetation surrounding the site has been classified as an Interior Douglas-Fir (Pseudotsuga menziesii) Zone (Dick 1978) and consists of meadows, shrub thickets, and mixed deciduous and coniferous forests.

Control of black bear activity at the dump is administered by the Ministry of Environment, Kootenay Regional Policy for Nuisance Black Bear Control (Wood, 1980). The policy states that the Ministry "will take such measures as are necessary to discourage bears from frequenting waste disposal sites. Black bears that have obviously become habituated to feeding at these sites will be destroyed." Grizzly bears are to be

Fig. 7. Map of the Sparwood Sanitary Landfill site.


Commercial Garbage Pile
OBSERVERS TRUCK
TEST TRAYS
TEST TRIGGER CABLES
Trees
Public Garbage Pile
Slope
Non-food Garbage
Road
Gate
Ditch
Sparwood 1.5 Km
Highway 3
50 Meters

relocated whenever possible. During 1980 and 1981, 20 to 30 black bears were destroyed at the site each year. No bears were destroyed in 1982 so that our tests could be conducted without disturbance.

METHODS AND MATERIALS

Tests were conducted on 30+ free-ranging black bears from early August to mid-November, 1982 (Appendix 8). During 2 weeks prior to testing, 9 bears were culvert-trapped and immobilized using a blow gun system (Carriles in prep.). Bears were marked for positive identification with a tattoo on the inside of the upper lip, and with plastic cattle ear-tags approximately 5 x 5cm, variously colored, and numbered prominently on 1 side. Data recorded for each bear included, sex, age, color and markings, and various physical measurements. A first premolar was extracted to determine age from cementum annuli (Stoneberg and Jonkel 1966).

Bear observations were made from dusk (at approximately 2000), to 0300, or until bear activity at the site had slowed. Bear behavior was observed from a vehicle parked approximately 50m from the trays. Observations were facilitated by military-issue, night vision goggles and 10 x 50 power binoculars.

Bears were identified by number and categorized as adults, subadults, or cubs (Appendix 8). Sibling cubs were treated as 1 unit. Descriptions (and drawings when appropriate) of each bear's color, markings, physical characteristics, and behavior at the site, including interactions with other bears, served to distinguish unmarked bears and to categorize them into approximate age classes. Of the 30 bears frequenting the garbage dump, only 3 proved difficult to distinguish. During data analysis, bears that had been difficult to assign to an adult or subadult category were classified as adults.

Bears were baited to the test site using numbered, 75cm x 75cm stainless steel trays filled with a homemade syrup mixture. The syrup was scented with anise and peanut butter, intended to present a novel food odor. Trays were placed about 15m apart and their order was changed nightly.

Tests were of passive deterrents and remote triggered repellents. Each passive stimulus was placed in a tray and mixed at 1 part stimulus to 2 parts syrup, and on the ground around another baited tray. Trays with stimuli mixed in the baits were presented as taste deterrent tests, while trays with the stimuli around them tested the stimuli as odor deterrents. Passive deterrents included 2 types of ammonia (full strength, and with household detergent), Bear Skunker, Boundry (commercial dog deterrent), human urine (male and female), mothballs, and Technichem (potential commercial bear deterrent). Baited trays with no stimuli were presented as controls.

Pain inducing repellents were actively delivered when a bear attempted to take a bait. Delivery devices were stationed at trays and remotely triggered by a fine cable attached to our truck. Triggered repellents were Halt and Bear Skunker. Attempts to test rock salt fired from a shotgun were discontinued, when the necessary range and accuracy at distances greater than 10m could not be achieved due to ballistic problems associated with the weight of the salt load.

Test site conditions prevented accurate determination of bears that were deterred from closely approaching a specific tray because of its odor. Therefore, reactions to stimuli were only recorded when bears approached to within 2m of a test tray.

Reactions to stimuli were recorded by scoring each bear's approach to a tray and subsequent type of response to the stimulus. Approaches were scored as direct (no visible hesitation during approach) or indirect (visible hesitation). The type of test response was scaled from 1 to 4 (repel to charge); scores had slightly different meanings, depending on whether the test stimulus was passive or active (Appendix 12). Also recorded were the length of time spent at each tray and the location the bear travelled to after being deterred or repelled by a stimulus.

Data were entered into the University of Montana's Dec-20 Computing System, and most of the analyses were done using the Statistical Package for the Social Sciences (SPSS, Nie et al. 1975). Analyses of test responses were limited by the small data base. Testing and analyses during this baseline study were exploratory, serving to build a foundation for further tests. Analysis of results was focused on the effectiveness of the test stimuli and on possible reasons for response differences between age classes and individual animals.

RESULTS

General Use of Site and Test Trays

Of 30 bears identified and tested, 9 were marked with eartags (Appendix 8). Only 1 of the marked bears was a female; 33% were adults, 67% were subadults, and none were cubs. The division by age class was approximately reversed for unmarked adults and subadults.

An average of 8 different bears visited the site per night (Table 7). Approximately 57% were adults, 34% subadults, and 16% cubs. An additional 4 to 5 bears were seen too briefly, or at too great a distance, to describe. These bears were included in daily counts, and when possible, an age class was assigned.

Use of the site by family groups remained consistent throughout the observation period (Table 7). The number of adult and subadult bears using the site decreased following the second and first period,

TABLE 7. Mean number of bears of certain age classes using the dump each night for each test period.

TEST PERIOD	NUMBER OF TEST NIGHTS	NO. OF BEARS USING DUMP EACH NIGHT						
		$\bar{x}$ Bears Each Night				% of Total Bears		
		All	Adult	Subadult	Cub	Adult	Subadult	Cub
All periods (9/22-11/1)	21	8.4	4.8	2.9	0.8	57	34	9
Period 1 (9/22-26)	5	13.8	7.2	4.8	0.8	56	38	6
Period 2 (9/27-10/2)	6	9.7	6.2	2.5	1.0	64	26	1
Period 3 (10/11-13)	3	5.0	2.0	2.0	1.0	40	40	20
Period 4 (10/15-18, 10/30)	5	4.6	2.6	1.4	0.6	57	30	13
Period 5 (10/31-11/1)	2	8.0	4.0	4.0		50	50	

respectively, and then remained relatively consistent until the last period when, for both classes, numbers increased slightly. Certain bears used the site more consistently than others. Only 4 bears were present on over 45% of the test days (Appendix 13).

The seasonal availability of natural foods in the area appeared to influence the number of bears using the site. The decrease in numbers following the first and second period coincided with the ripening of berries at higher elevations, and the reduced availability of berries in areas around the dump. An increase in the percent of scats found on the site and around the dump which contained only garbage suggested that the bears still using the site were subsisting almost entirely on the dump. Earlier, many of the bears appeared to be using the dump in conjunction with natural foods in the area. The first snowfall occurred during 5 October to 8 October. Bears probably also left the site to initiate denning activities. Following a heavy snowfall on 28 and 29 October, use of the site increased slightly, possibly due to the reduced availability of food elsewhere. Though undocumented, on nights when the garbage pile had been buried by the bulldozer, both the number of bears using the site, and overall time spent at the site by bears appeared to decrease.

Generally, all test trays were visited as the night progressed. The sequence of visits to trays appeared to be a function of their location. Trays closest to the timber or to the garbage pile were used first. Trays were visited 475 times. The number of visits to trays, and length of time spent at each, were dependent upon the type of stimulus in the tray and on the individual bears visiting the trays.

The control trays and other stimuli that evoked minimal deterrent responses (less than 25% were deterred), were visited by approximately equivalent numbers of bears per period and the bears stayed for an average of 1.5 to 2.0 minutes (Table 8). However, when compared to the controls, the number of bears deterred and the number of visits, were usually slightly higher than to trays with stimuli placed around them, and higher still for those with the same stimulus mixed in the bait. This suggested that certain bears were at least initially wary of or deterred by baits contaminated with a novel odor, and yet a greater number deterred by a novel taste.

For the stimuli that deterred most bears, visits and the time spent at trays were variable. Individual bears and bears of certain age classes exhibited different tolerances to certain stimuli. The patterns of responses generally fell into 3 categories: low numbers of bears visited a tray and stayed only short periods of time; low numbers visited a tray and stayed long periods of time; or high numbers visited a tray and stayed only short periods of time.

TABLE 8. Mean number and length of visits (minutes), number of visits by certain age classes, and visits during each test period, to each stimulus.

STIMULUS	NUMBER OF TEST NIGHTS	NUMBER OF VISITS	$\bar{X}$ VISITS PER NIGHT	$\bar{X}$ TIME PER VISIT	% VISIT PER AGE CLASS			NUMBER OF VISITS TO EACH STIMULUS BY TEST PERIOD				
					Adult	Subadult	Cub	Period 1 9/22-26	Period 2 9/27-10/2	Period 3 10/11-13	Period 4 10/15-18, 10/30	Period 5 10/31-11/1
Control 1	21	52	2.5	1.7	42	50	8	26	12	4	8	2
Control 2	16	29	1.8	2.1	55	31	14	1	16	6	3	4
Boundary--on	5	25	5.0	1.8	52	44	4	25				
Boundary--around	5	18	3.6	1.9	28	72		18				
Mothballs--on	5	24	4.8	3.4	50	50		24				
Mothballs--around	5	19	3.8	1.6	32	68		19				
Technichem--on	5	19	3.8	2.0	32	68		20				
Technichem--around	5	33	6.6	2.1	52	48		33				
Urine, Male--on	5	23	4.6	0.8	39	57	4	23				
Urine, Male--around	5	37	7.4	2.2	57	41	2	37				
Urine, Fem--on	6	8	1.3	0.5	50	38	12		8			
Urine, Fem--around	6	16	2.6	2.1	69	6	25		16			
Ammonia, Parsons--on	6	6	1.0	1.4	33	67			6			
Ammonia, Parsons--around	6	18	3.0	0.7	50	44	6		18			
Ammonia, Wizard 1--on	8	19	2.3	1.8	68	32				3	16	
Ammonia, Wizard 2--on	8	22	2.8	1.2	50	27	23			5	17	
Skunker--on	6	24	4.0	1.5	54	42	4		23			
Skunker--control	13	13	1.0	0.8	15	85			4		3	6
Skunker--trigger	13	37	2.8	---[a]	41	49	10		11			
Halt--control	9	12	1.3	2.6	50	33	17		8	4		
Halt--trigger	10	21	2.1	---	48	52				8	7	6

[a]Not considered.

Visits to trays by subadults were approximately equal to visits by adults, each making up 47% of the total (Appendix 14). This tended to be slightly higher in proportion to the number of subadults observed using the site, and was due to adult bears commonly causing subadults to move from 1 tray to another. Visits by family groups were generally under-represented, as these bears usually did not compete for the trays. Perhaps because they were disturbed less often, adults averaged longer times on the test trays (mean=2.5 minutes) than subadults (mean=1.4 minutes).

Responses to Passive Tests by All Bears

Bears approached the trays by direct investigation (no visible hesitation) in 87% of the visits (Table 9). Bears displayed a higher frequency of indirect investigations (visible hesitation) when approaching trays with Parson's Ammonia, male human urine, and Wizard Ammonia on the bait. These were approached directly during only 33%, 52%, and 68% of the tests, respectively.

Responses to passive stimuli indicated that the male human urine and full strength Parson's Ammonia applied on baits were the most effective stimuli tested. Bears that approached these trays walked away without eating, or ate briefly then left, during 78% and 67% of the tests, respectively (Table 9). High numbers of bears visited the former trays and usually stayed only a short time. Only a few bears visited baits with Parson's Ammonia on them, suggesting that the odor alone

TABLE 9. Type of approach response (%) and test response (%) to each stimulus by all bears.

STIMULUS	NUMBER OF TESTS	APPROACH		TEST RESPONSE[a]			
		Indirect investigation	Direct investigation	Deterred/repelled 1[b]	Deterred/repelled 2[c]	Not deterred/repelled 3[d]	Not deterred/repelled 4[e]
Control 1	52	10 (19)[f]	42 (81)	8 (15)	5 (10)		39 (75)
Control 2	29	3 (10)	26 (90)	2 (7)	2 (7)		25 (86)
Boundary--on	25	2 (8)	23 (92)	4 (16)	3 (12)		18 (72)
Boundary--around	18	2 (10)	16 (90)	1 (6)		2 (11)	15 (18)
Mothballs--on	24	2 (8)	22 (92)	3 (13)	2 (8)		19 (79)
Mothballs--around	19		19 (100)		1 (5)		18 (95)
Technichem--on	19	2 (10)	17 (90)	1 (5)			18 (95)
Technichem--around	33	2 (6)	31 (94)	3 (9)			30 (91)
Urine, Male--on	23	11 (48)	12 (52)	14 (61)	4 (17)	1 (4)	4 (17)
Urine, Male--around	37	4 (10)	33 (90)	9 (24)	5 (14)	1 (3)	22 (60)
Urine, Fem--on	8	1 (12)	7 (88)	3 (38)	1 (12)		4 (50)
Urine, Fem--around	16	1 (6)	15 (94)	1 (6)	1 (6)		14 (88)
Ammonia, Parsons--on	6	4 (67)	2 (33)	3 (50)	1 (17)		2 (33)
Ammonia, Parsons--around	18	4 (22)	14 (78)	5 (28)	5 (28)		8 (44)
Ammonia, Wizard 1--on	19	6 (32)	13 (68)	3 (16)	3 (16)		13 (68)
Ammonia, Wizard 2--on	22	3 (14)	19 (86)	3 (14)	2 (9)	4 (18)	13 (59)
Skunker--on	24	3 (13)	21 (88)	3 (13)	2 (8)	1 (4)	18 (75)
Skunker--control	13		13 (100)		4 (31)	1 (8)	8 (62)
Skunker--trigger	37		37 (100)	12 (32)	8 (22)	8 (22)	9 (24)
Halt--control	12		12 (100)	3 (25)			9 (75)
Halt--trigger	21	3 (14)	18 (86)	17 (81)	1 (5)	1 (5)	2 (10)

[a] Test response codes (all stimuli were passive except the triggered Skunker and Halt):

Passive Stimuli	Triggered Stimuli
[b] 1 = Walk away; no eat	[b] 1 = Run away
[c] 2 = Eat briefly; leave	[c] 2 = Walk away
[d] 3 = Eat hesitantly	[d] 3 = Orient to, eat hesitantly
[e] 4 = Eat continuously	[e] 4 = Orient to, eat continuously

[f] (Percent).

deterred some bears. Those not deterred generally stayed low to average lengths of time, indicating that certain bears tolerated the substance.

Placement of these stimuli (male urine and Parson's Ammonia) around baited trays deterred bears during only 38% and 56% of the visits, respectively (Table 9). High numbers of bears visited baits with male urine around them, staying average lengths of time, while an average number of bears visited trays with the Parson's Ammonia around them, these only staying short periods, again suggesting that for many bears the odor of the latter was noxious.

The only other passive stimulus that appeared to have deterrent potential was the female human urine applied on baits. Although bears were deterred only 50% of the time, low numbers of bears visited the trays. *Placement of this stimulus around trays deterred bears during* only 12% of the visits.

Passive stimuli that did not appear to have deterrent potential were the Bear Skunker, Boundry, Halt, mothballs, Technichem, and Wizard Ammonia (ammonia with a detergent additive). The Wizard Ammonia and the passive Bear Skunker stimuli deterred bears during 25% to 33% of the tests (Table 9). The rest of the stimuli deterred bears less than 25% of the time. With the exception of the Technichem, a stimulus mixed with a bait deterred bears more often than when applied around a bait.

Responses to Passive Tests by Age Category and Individual Bear

Visits and responses to specific stimuli by different age classes were not equally distributed (Table 10). Differences in the responses of adults and subadults to the most effective stimuli were compared. Average numbers of visits were made by adults and subadults to baits with male human urine on or around them; however, subadults were more often deterred by the stimulus. During visits, adults and subadults were deterred by male urine on a bait 67% and 85% of the time and by male urine around the baits 23% and 47% of the time, respectively (Table 10).

Few bears of either age class visited trays with Parson's Ammonia on them. Visits by adults were proportionately lower than visits by subadults. Adults and subadults were deterred during 50% and 75% of the visits, respectively. Average numbers of bears in both age classes visited trays with this stimulus around them; adults were deterred during 67% of the visits and subadults were deterred 38% of the time.

Trays with human female urine on the bait were visited by low numbers of adults and subadults. Proportionately, numbers of visits by subadults were lower than visits by adults, and 25% and 100% were deterred, respectively. While average numbers of adults and only 1 subadult visited trays with the stimulus around them; 18% of the adults were deterred, and the subadult was not.

TABLE 10. Type of test response to each stimulus by bears of certain age classes.

STIMULUS	ADULT					SUBADULT					FAMILY GROUP				
	Number of tests	Test Response[a] 1[b]	2[c]	3[d]	4[e]	Number of tests	Test Response 1	2	3	4	Number of tests	Test Response 1	2	3	4
Control 1	22	3(14)[f]	2(9)		17(77)	26	3(11)	2(8)		21(81)	4	2(50)	1(25)		1(25)
Control 2	16	1(6)	2(13)		13(81)	9	1(11)			8(89)	4				4(100)
Boundary--on	13	3(23)			10(77)	11	1(9)	3(27)		7(64)	1				1(100)
Boundary--around	5	1(20)			4(80)	13			2(15)	11(85)					
Mothballs--on	12	1(18)	1(8)		10(84)	12	2(17)	1(8)		9(75)					
Mothballs-around	6		1(17)		5(83)	13				13(100)					
Technichem--on	6	1(17)			5(83)	13				13(100)					
Technichem--around	17	2 (12)			15(88)	16	1(6)			15(94)					
Urine, Male--on	9	4(45)	2(22)		3(33)	13	10(77)	1(8)	1(8)	1(7)	1		1(100)		
Urine, Male--around	21	3(14)	4(19)		14(67)	15	6(40)	1(7)	1(7)	7(46)	1				1(100)
Urine, Fem--on	4	1(25)			3(75)	3	2(67)	1(33)			1				1(100)
Urine, Fem--around	11	1(9)	1(9)		9(82)	1				1(100)	4				4(100)
Ammonia, Parsons--on	2		1(50)		1(50)	4	3(75)			1(25)					
Ammonia, Parsons--around	9	4(45)	2(22)		3(33)	8	1(12)	2(25)		5(63)	1		1(100)		
Ammonia, Wizard 1--on	13	1(8)	1(8)		11(84)	6	2(34)	2(33)		2(33)					
Ammonia, Wizard 2--on	11	1(9)		2(18)	8(73)	6	2(34)	2(33)		2(33)	5			2(40)	3(60)
Skunker--on	13	3(23)	1(8)		9(69)	10	1(10)	1(10)		8(80)	1			1(100)	
Skunker--control	2		1(50)		1(50)	11		3(27)	1(9)	7(64)					
Skunker--trigger	15	5(33)	4(27)	2(13)	4(27)	18	7(39)	4(22)	4(22)	3(17)	4			2(50)	2(50)
Halt--control	6	1(20)			5(80)	4	2(50)			2(50)	2				2(100)
Halt--trigger	10	10(100)				11	7(64)	1(19)	1(9)	2(18)					
Total	223					223					29				

[a]Test response codes:

Passive Stimuli
[b]1 - Walk away; no eat
[c]2 - Eat briefly; leave
[d]3 - Eat hesitantly
[e]4 - Eat continuously

Triggered Stimuli
[b]1 - Run away
[c]2 - Walk away
[d]3 - Orient to, eat hesitantly
[e]4 - Orient to, eat continuously

[f](Percent).

Adult bears made an average number of visits to baits with Wizard Ammonia on them and were deterred approximately 13% of the time. Subadult use of these trays was low; bears were deterred during 67% of the visits. Conversely, the number of visits to the Skunker control trays, and trays with Skunker mixed with the bait, was low and high respectively; adults were deterred proportionately more often than subadults by both tests.

Only adult (AD) Bears 4 and 12, and subadult (SA) Bears 5 and 10, were present on over 45% of the test days (Appendix 13). These bears accounted for about 38% of the visits to the test trays (Appendix 14). Recurrent use of specific trays by certain bears suggested that some bears were more tolerant of noxious stimuli than others. Bears 10 (an aggressive male), and 12 (thought to be a dominant male) accounted for 48% of the visits to trays with male urine on the bait. Bear 12 accounted for 60% of the deterred visits to this stimulus. Only 5 bears visited trays with the Parson's Ammonia on the bait; 33% of the visits were by Bear 9 (SA), and 100% of the non-deterred visits were by Bears 9 and 40 (AD). Both bears appeared to be low-ranking animals that reacted submissively to the advances of most bears. Only 6 bears visited baits with the female urine on them; 38% of the visits were by Bear 5; 100% of the deterred responses were by Bears 5 and 4 (also low-ranking bears). Of the 7 bears that visited trays with female urine around them, only Bear 12 was deterred. In tests of the Wizard Ammonia, 100%

of the non-deterred responses were by the low-ranking Bear 40 and the generally non-competitive Bears 22 and 23 (female with cubs).

Responses to Active Tests by All Bears

Bears were allowed to eat at the remote-triggered baits until they could be sprayed in the eyes. No aggressive reactions were displayed in response to any of the triggered tests. The triggered Skunker repelled bears 54% of the time (Table 9). When repelled, 25% of the time bears backed off, then returned to the same tray in less than one minute; 50% went immediately to another tray or to the garbage pile (Appendix 15). The remaining 25% left the site, returning on the average, 11 minutes later. Bears often returned to the triggered Skunker tray shortly thereafter.

Bears were repelled by the triggered Halt during 18 of 21 tests (Table 9). When repelled, bears usually ran 20 to 25m toward the timber, then stopped briefly to paw at their eyes. Then, during 61% of the tests, they ran into the timber without looking back; during 39% of the tests, they went directly to the garbage pile, another tray, or the site perimeter (13% each; Appendix 15). During the 3 tests where bears were not repelled, the spray appeared to have contacted the animals in the upper neck region. These bears had been hit with triggered stimuli several times before and when sprayed, they merely hesitated briefly, then resumed eating.

When bears were repelled by Halt, during 86% of the tests the animals returned and resumed foraging at the site on the average, 17 minutes later. In the remaining 3 cases, 1 bear returned 24 hours later, and 2 were never seen again. (However, these 3 tests were delivered during the last 2 days of testing.) Upon re-entering the site, 50% first returned to the garbage pile; the other 50% returned to another test tray. Bears generally did not return to the triggered Halt tray until some time later in the evening.

Responses to Active Stimuli by Age Category and Individual Bear

Adult and subadult bears reacted similarly to tests of the triggered stimuli. Average numbers of bears of each age class visited the trays (Table 10). The triggered Skunker repelled 60% and 61% of the adult and subadults bears, respectively. During 4 tests of the Skunker trigger on cubs, none were repelled. Adults and subadults were repelled by the triggered Halt during 100% and 73% of the tests, respectively.

Visits by Bears 4 (AD), 5 (SA), 35 (SA), and 21 (cub), made up 65% of the triggered Skunker tests (Appendix 14); 27% of the trials were by Bear 5. Although this low-ranking bear was repelled in 70% of the tests he visited the tray repeatedly.

Bears 5, 10 (SA), and 44 (AD) accounted for 67% of the visits to the triggered Halt trays. The latter 2 were aggressive bears. The 3 tests where bears were not instantly repelled were on Bears 5 and 10

(Table 9).

All trays were checked at 0700 each morning, 11 hours after they had been placed at the site. Only the Parson's Ammonia mixed with the bait consistently reduced bait consumption during the 11 hours each night that the baits were available to the bears. Generally, trays were empty each morning except for trays with the Parson's Ammonia in them. These always remained at least half full. Exceptions to the above were trays with human female urine and Wizard Ammonia on them, and the triggered Skunker tray, in which a small amount of bait remained in 33%, 13%, and 17% of the cases, respectively.

DISCUSSION

Animals function best where the predictability of the environment is maximized and stress is minimized (Geist 1970, McArthur 1979). Previous experience, as well as an immediate stimulus, determine behavior. Learning is the modification of current behavior by previous experience in the same situation (Scott 1972). Consistent use of methods that reduce the attraction of bears to human-associated food sources should reduce human-bear conflicts, minimizing stress on bear populations.

Bears initially approach human-linked situations with trepidation (Tate and Pelton 1979, Stenhouse 1982). Effective repellents and deterrents should prevent naive bears from acquiring unwanted behaviors, and stop bears that already exhibit undesirable behavioral patterns. Repeated repellent or deterrent treatments should deter bears from the action permanently through learning (e.g. aversive conditioning).

During studies of black bears in the Smokies, Tate and Pelton (1979) observed that bears varied in the extent to which they used human food sources and in their tolerance of human activities. Certain bears consistently appeared less capable of adapting to human-linked situations. During tests of deterrents and repellents Miller (1980) and Stenhouse (1982) noted repeated returns by specific bears. Miller further remarked that certain individuals could not be deterred or repelled.

During this study similar differences between bears relative to their ability to tolerate human-linked situations, were reflected in their use of the dump site and responses to test stimuli. These differences, combined with environmental influences such as seasonal changes in natural food availability and weather extremes, appeared to govern the overall number of bears using the dump. Certain bears were observed consistently using the dump site; others were seen only intermittently. Beds, scats, and other bear sign found on the site and in the surrounding area, suggested that some bears relied primarily on the dump for food, while others appeared to use the site as they travelled through the area, or as an alternative food source in conjunction with natural foods in the area. Hence, during certain times of the year when bears were drawn into the area by an increased availability of natural foods, the number of bears using the dump site also increased.

Bears visiting the trays for the first time or only occasionally, were generally cautious when approaching the more noxious trays and often stayed for shorter periods. Certain bears that consistently used the site, apparently dependent on garbage as a major source of food throughout their active season, often tolerated the most noxious baits or repeatedly returned to visit the remotely triggered stimuli.

Bear activity at the garbage dump was largely regulated by social hierarchies. Responses to tests were primarily dependent on the type of stimulus, in combination with tolerances by individual bears and the behavior of other bears present at the site. Activities by dominant animals affected the trapping and tagging efforts, as well as the number of visits to, and time spent at specific -est trays by bears. Low ranking bears and family groups appeared to avoid conflict with dominant bears by using alternative, and often less optimal, food opportunities such as those presented by our culvert trap and the most noxious test trays.

Non-effective, passive deterrent stimuli were generally approached directly, and were visited by an average number of bears in a night. These stimuli deterred more bears when mixed with baits than when placed around them; suggesting that certain bears were, at least initially, wary of the chemical taste. Proportionately, numbers of visits by subadults were higher and their stays at trays shorter than for adults, because they were forced off these palatable baits by dominant animals.

Effective passive stimuli that deterred most bears were visited inconsistently, depending on the stimulus and the individual bear. In general, bears stayed at these for shorter periods. Differences in tolerance levels by age classes or individuals were evident. Certain bears would not eat from trays with certain stimuli.

Passive stimuli that deterred most bears during or shortly after approaches were the male human urine and the full strength Parson's Ammonia placed on baits. These deterred 18 of 23 bears, and 4 of 6 bears, respectively. Although proportionately more bears were deterred by the urine, high numbers of bears visited the stimulus. Few bears visited the ammonia trays; the odor cue alone was apparently effective in deterring some bears. Only the Parson's Ammonia mixed with baits consistently reduced bait consumption by deterring most bears from eating throughout the 11 hours each night that the baits were available to them. Both adults and subadults were highly deterred by these stimuli, but proportionately, subadults were more frequently deterred. The Parson's Ammonia applied around baits also appeared relatively effective. However, a higher number of bears visited these baits and many subadults appeared to tolerate the chemical odor in order to eat the bait. Although female human urine mixed in baits deterred only 4 of 8 bears, only a small number of bears visited these trays. Bears may have been deterred by the odor. All subadults, but only 25% of the adults were deterred by this stimulus.

Actively delivered Halt repelled most bears from the site. Bears generally returned within 17 minutes, but none returned initially to the same tray. Most bears sprayed with Skunker responded by merely moving to another tray or to the garbage pile. The majority returned soon afterwards to the same tray. Although most bears were initially repelled by Skunker, several subadults that consistently used the dump (and some of the most noxious test trays), were not repelled in subsequent tests; the stimulus failed to repel cubs during all tests. These bears tolerated the disturbance; the positive reward of the bait appeared to outweigh the negative effect of the stimulus.

The results of tests suggest that a combination of full strength ammonia (a taste and odor deterrent) and actively triggered Halt (a pain-inducing repellent), may turn most bears during or shortly after approaches, and subsequently deter most close approaches. Further, large-scale testing of these promising stimuli at the site is necessary. The ammonia should be placed on (or if not possible, around or near to) the food resource. Initially, consistent application of the remotely triggered capsaicin (in a form that can be accurately sprayed at bears from 10+m) will be required to repel bears that return to the site. If an additional cue is presented simultaneously with delivery of the capsaicin (such as an auditory cue), then bears may be conditioned to be repelled by presentation of this cue even if direct application of the capsaicin has not occurred.

In general, subadults appeared to be more easily deterred by noxious stimuli than adults. However, certain low-ranking individuals that used the dump consistently, often returned to use the most noxious trays. Differences in responses to stimuli between bears, such as to the male and female urine, the Skunker, and to the different tests of ammonia, may reflect the influence of hierarchical status and life experiences on bear responses, and may be important in the development of effective stimuli. Biologically meaningful stimuli such as the urine and Skunker may prove to be easily incorporated into the learning process and have wider application among individuals.

Certain bears may not be deterred unless they are physically obstructed from entering a site, or are constantly repelled with highly effective pain-inducing stimuli. Such bears may be more dependent on the food resources at the site than others. If efforts to deter bears using preventative measures fail, relocation or destruction of the animals may be necessary.

The data suggest that certain measures may reduce the attractiveness of the site to bears. Increased rates of garbage burial and consistent application of deterrents or repellents to foods at the site, may be effective in preventing initial use by naive bears and in reducing the overall number of bears frequenting the site. Increased rates of application of these preventative measures during seasons when natural foods attract bears to the area, may increase their effectiveness.

Responses to stimuli will be influenced by the individual bear, the availability of alternative food sources in the area, the palatability and nutritive value of food at the site, and the behavior of other bears in the area. Brief surveys for bear sign in areas surrounding planned or existing sites that have the potential to attract bears, may serve to predict bear behavior patterns and potential conflicts, and to develop preventative strategies.

PART IV

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

The purpose of this project was to develop a testing format on which further studies could build and to test stimuli with potential as bear repellents and deterrents. Test conditions and stimuli were developed to address the 2 principal situations that cause human-bear conflicts: surprise encounters and bear use of human food sources. When the opportunity arose to release certain captive bears back into the wild, the possibility of aversively conditioning bears to avoid humans was also explored.

Suitability of Test Procedures

Results of this project agree with Miller's (1980) observations: laboratory tests of repellents on angry captive bears are an effective method for testing several stimuli in a short time and for distinguishing which stimuli may be effective repellents for free-ranging bears. In addition, the results of tests of problem bears before they are destroyed, allow progress to be made toward a long-term solution to the problem of human-bear conflicts.

The apparent success of the aversive conditioning program on captive problem bears suggests that this may be an effective method for initial conditioning of certain problem bears from approaching humans once released into the wild. Observation of bear behavior during laboratory tests may provide a basis for evaluating the suitability of specific bears for successful aversive conditioning programs.

By testing repellents and deterrents at dump sites, many stimuli can be can be tested on free-ranging bears without disturbing bears in critical natural habitats where they may concentrate. Dump sites also provide the opportunity for rapid further testing of promising laboratory repellents on free-ranging bears. This is a first step toward later tests on angry or surprised, free-ranging animals. Dump conditions may expose limitations of stimuli that were not apparent during laboratory tests. Where laboratory data are difficult to interpret, further tests in the field may clarify the responses.

Both the laboratory and dump situations provide opportunities for observing bear behavior. Throughout this study bears were quite predictable as individuals, but not as a group. The causes and effects of individual variation between bears in terms of responses to stimuli, humans, food, and interactions with other bears can be explored.

Summary of Results and Implications for Management

Laboratory results indicate that stimuli can be developed that will repel most bears. Halt, a product containing capsaicin, and a Bear Skunker (synthesized skunk spray)/Halt combination were highly repellent stimuli. Inclusion of an odor cue with a repellent stimulus seemed to increase its effectiveness. Effective stimuli appeared to reduce aggression and the frequency of immediate charges in a subsequent encounter. Bears that were not repelled or submissive in response to a stimulus displayed an increased frequency of aggressive interactions and immediate charges during the following encounter. Responses to test stimuli were dictated by the effectiveness of the stimulus in combination with the character of the individual bear. Certain non-aggressive bears were repelled consistently more easily than others.

With its present delivery system, Halt does not have the necessary range or accuracy to be effective on free-ranging bears. Canisters with more concentrated solutions of capsaicin and longer, wider, spray distances should be developed. By simultaneously combining additional visual, odor, or auditory cues with the use of the capsaicin, many bears may be repelled from approaching during initial or subsequent encounters without direct application of the spray.

In the laboratory, bears signalled their submissive or aggressive intentions by presenting their bodies at certain angles, making specific, repeated head movements, and making or avoiding eye contact with the tester. Similar actions by the tester appeared to have signal value for bears. The tester elicited aggression in most bears by standing and directly facing them while stomping, or by turning away from them following such a presentation. Aggressive or non-aggressive approaches were elicited by assuming a crouching, sideways stance combined with a repeated turning of the head and eyes, briefly toward and then away from the animal.

Test period data and various confrontations with captive bears following test periods, suggest that during an encounter with a bear when an immediate charge does not occur, an effective signal for communicating peaceful intentions and not eliciting an approach may be to stand sideways and to display the previously mentioned head movements. Then, while maintaining the stance and talking to the animal, attempt to leave the site.

None of 4 bears subjected to the captive aversive conditioning program and then released, has been involved in further human-bear conflicts or been harvested. The program appears to have been a success, however the ultimate fate of these bears is unknown. Observation of bear responses to tests in the laboratory appeared to provide a basis for determining the temperament of individual bears, which was correlated with their responses during the aversive conditioning program.

Successful laboratory aversive conditioning programs may require that: bears be non-aggressive, the timing of their release minimize the potential for conflicts with humans or other bears, and overconditioning during tests be avoided. Due to the introductory nature of this research, to determine the effectiveness of this approach bears should be monitored following their release. Further aversive conditioning in the wild may be necessary.

Data from the field tests indicated that certain taste deterrents applied to baits deterred most bears during or shortly after approaches, thereby reducing overall bait consumption and subsequent use. Most bears were deterred from eating by the male human urine or full strength Parson's Ammonia applied to baits; the ammonia odor appeared to deter many bears from approaching. Only the Parson's Ammonia reduced bait consumption throughout the 11 hour period each night that baits were available to bears.

Tests of the pain-inducing stimulus Halt effectively repelled bears both in the laboratory and in the field, but bears appeared to recover quickly. Although its application generally caused bears to leave the dump site, most bears returned to use the garbage pile or alternative trays within 17 minutes of the test.

A combination of the pain-inducing repellent capsaicin and full strength ammonia as a taste deterrent and constantly advertised odor deterrent, may have potential for reducing the number of initial visits by naive bears, and return visits by bears frequenting the site. Further tests of this combination should be conducted on a large scale at a dump or dumpster site. To be effective, the capsaicin must be remotely triggered and in a form that can be applied to a bear's face at ranges up to 10m. An odor or other additional cue could be added to the capsaicin to increase its effectiveness. Once hit with the capsaicin/stimulus combination, bears may then be repelled by delivery of the stimulus, whether or not they are accurately sprayed. The ammonia (to reduce bait consumption) should be applied on or as close to the attractant food source as possible.

Use of the site and responses to test stimuli appeared influenced by the availability of alternative foods in areas surrounding the site, dominance activities by bears in the area or using the site, and differences between individual bears. Certain (often low-ranking) bears that may have been more dependent on the dump for food than others, repeatedly returned after being sprayed with repellent stimuli. This suggests that certain bears may not be deterred from subsequent approaches, and perhaps, that aversive conditioning with repellents may not be feasible on them. Relocation or destruction of these bears may be necessary.

General Recommendations for Reduced Human-Bear Conflicts

Repellents and deterrents should be used as tools to aid, not substitute for, preventative measures that reduce the potential for human-bear conflicts. Situations that create the potential for problems, and therefore the need for repellents and deterrents, can be identified and must be minimized, to achieve overall success. To effectively reduce conflicts on a large scale, three basic preventative management efforts are needed:

1. the reduction of bear access to human food sources, especially garbage, on public and private lands;

2. increased efforts to educate the public as to the effect of their activities on bear populations; and

3. increased agency commitment and interagency cooperation in reducing conditions that are attractive to bears.

These are not exclusive and should be applied in combination with each other (and deterrents and repellents if necessary) where the potential for human-bear problems exists.

Where feasible, bears should be physically excluded from sites that pose a constant attraction. Electric fencing provides the most effective option at present, but where it would not be feasible or the cost would be prohibitive, implementation of repellent and deterrent methods should be considered.

Bear access to garbage must be minimized wherever possible. Proper attention to garbage removal should include: accelerated pickups or burial during seasons when bear use of natural foods in the area increases; leaving little garbage for overnight bear use; splitting garbage bags when dumped so that "shy" bears cannot handily take these "purses" off the site into the surrounding cover (where additional bears may be introduced to the resource); and locating garbage piles and dumpsters away from cover. Contingent on further research, regularly applying effective taste and odor deterrents at garbage sites may also reduce the attractiveness of the site. Deterrence of certain bears may require consistent application of a pain-inducing stimulus until the bears no longer visit the site. Periodic reapplication of pain-inducing stimuli may be necessary.

Public education programs should be intensified. The public must realize the critical impact that bear use of human food sources has on human-bear coexistence. This is a difficult, delicate, task to address because it involves personal attitudes and rights. The problem would not be overstated if agencies were to emphasize the fact that feeding a bear is almost equivalent to killing it. The public must also understand that repellents and deterrents do not necessarily make them or their camps "bear proof"; that proper food handling procedures must still be followed; and that incorrect use of repellents, such as using repellents as a back-up to allow closer viewing of bears, will place further stress on bear populations. Increased opportunities to view bears from a distance, as has been done in Glacier National Park, may help to increase acceptance of these restrictions.

Agencies must take a positive, not a defensive position in managing bears. Preventative measures that reduce the potential for bear problems should be incorporated into planning documents. Such actions have significantly reduced problems in our national parks, but should not stop at agency lines, as they frequently do now. Interagency cooperation should increase public acceptance and cooperation with these efforts.

"Bear-proof" procedures for food handling (including garbage) and food storage, and against bear feeding, should be implemented and enforced on both public and private lands. Violators must be effectively disciplined or fined.

Further research on repellents, deterrents, and aversive conditioning methods should be thoroughly coordinated and documented, and information gathering should be standardized between agencies. Investigations should initially be concerned with developing methods that are flexible and can be used in several types of situations, are cost effective, are easy to operate, and require a minimum of maintainance.

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APPENDICES

APPENDIX 1. Descriptions of test stimuli.

Ammonia: Parson's Ammonia. Full strength ammonia. Ingredients: Ammonium hydroxide solution, Ethoxylated alkyl alcohol, Perfume, Color, Clarifying Agent, salts (inert), contains 0% Phosphorus per recommended use. Distributed by Armor and Dial, Phoenix, AZ.

Wizard Ammonia. Ingredients: approximately 6% ammonia, 94% household detergent. Distributed by Alliance Int. Sales Ltd., Vancouver, B.C.

Technichem Bear Repellent: A secret formula designed to deter bears from eating food items to which it has been applied. Distributed by Technichem Corp., Boise, ID.

Bear Skunker: A potential natural repellent for bears in a spray bottle. Ingredients: the active components of natural skunk scent. Distributed by Bear Country Products, Orinda, CA.

Bear Tape: A one-minute tape recording of a caged male grizzly bear vocally challenging a person outside its cage.

Boundary: A commercial, aerosol, dog and cat deterrent, for application to "forbidden" areas. Active Ingredients: 1.9% methylonyl Ketone; 0.1% related compounds, 98% inert ingredient. Distributed by Lambert Kay, Cranbury, N.J.

Shield: A commercial, aerosol, non-lethal, riot control agent. Ingredients: 1% orthochlorobenzalmalononitrile (CS) in a non-toxic solvent. Distributed by We Care America, Chesterfield, MO.

Radio Music: A one-minute recording of instrumental and vocal, rock and roll music. (Donna Summers, "Bad Girls").

Flare: A handheld, commercial highway flare, that ignites when struck. Distributed by Olin Corp., Peru, Indiana.

Halt: A commercial, aerosol, dog repellent. Ingredients: .35% Capsaicin (derived from Oleoresin of Capsicum), 99.65% inert ingredients. Distributed by Animal Repellents, Griffin, GA.

Human Urine: Male and female: less than one week old, kept cold, and in airtight canning jars until use. Donated by friends.

Appendix 1. (Continued).

Moth Balls: Enoz Brand. Ingredients: 100% Naphtalene. Distributed by Home Products Inc., St. Louis, Mo.

Miracle Brand. Ingredients: 100% naphtalene. Distributed by The Sterling Co., St. Louis, Mo.

Air horn: Falcon 3 Commander: A moderate, to high pitched pocket-sized, portable, freon-powered horn. Distributed by Falcon Safety Products, Inc., Mountainside, N.J.

Umbrella: A handheld, black umbrella, that opens to approximately .75m.

APPENDIX 2. Bears tested during captive bear studies, June, 1981, to December, 1982.

BEAR NO.	COAT COLOR	WEIGHT (LBS.)	AGE	SEX	DEPREDATION	CAPTURE	DISPOSITION
Black Bear							
01 (588-Ace)	Black	150	3.5	M	killed penned steer	MDFWP, Lincoln, MT	relocated to Olympic Game Farm, WA.
02 (131-Barney)	Black	125	9.5	M	campground nuisance	MDFWP, Thompson Falls, MT	relocated to Lolo Pass Area, MT
03 (107-Cub)	Chocolate brown; small white on chest	75	1.5	F	orphan; root cellar break-in	Conf. Salish & Kootenai Tribes Flathead Reservation, MT	relocated to Flathead Reservation, MT
[illegible] (04-Davey)	Chocolate brown; large white on chest	125	4.5	M	killed calf	Conf. Salish & Kootenai Tribes Flathead Reservation, MT	destroyed
[illegible] (266-Easy)	Chocolate brown	100	4.5	F	roadside panhandler	Glacier National Park, MT	relocated to Bear Country USA, S.D.
06 (06-Fredda)	Liver brown; large white on chest	110	10.5	F	killed calf	Conf. Salish & Kootenai Tribes Flathead Reservation, MT	destroyed
Grizzly Bear							
07 (81-George)	Chocolate brown/ silver-tipped	485	4.5	M	campground nuisance; cabin and vehicle break-ins	Yellowstone National Park, MT	destroyed
81 (531-Cub)	Chocolate brown/ silver-tipped	85	Cub	F	orphan; campground nuisance	MDFWP, Cabinet Mountains Area, MT	relocated to Swan Valley Area, MT
82 (530-Cub)	Chocolate brown/ silver-tipped	75	Cub	F	orphan; campground nuisance	MDFWP, Cabinet Mountains Area, MT	relocated to Swan Valley Area, MT

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APPENDIX 1. Test observations- Laboratory Data Form.

	TEST RESPONSE				
	1	2	3	4	5
IR					
TR					
CR					
RR					

BEAR:
OBSERVER:
TESTER:
DATA:

TEST:
T NUM:
T REP:

TEMP:
OUTTEMP:
OUTCLOUD:
OUTWIND:

HR/MIN	TEST PER	OA	GBP	TA	TP	HP	HO	EP	VOC	FFP	BFP	MISC	NOI	RM/QUAD	IA	TFL	BEGR	TOTR	COMMENTS

APPENDIX 4. Labels of variables on Laboratory Data Form

Abbreviation	Explanation
BEAR	ID number for bear
CUB	ID number for cub in family
DATE	Julian date
HOUR	Time of test (24 hr.)
MINUTE	Time of test
OUTTEMP	Outside temperature conditions
OUTCLOUD	Outside cloud conditions
OUTWIND	Outside wind conditions
TEMP	Temperature inside cell (Fahrenheit)
TPER	Test condition
TEST	Repellent tested
OA	Overall Activity
GBP	Gross Body Position
HP	Head Position
HO	Head Orientation
EP	Ear Position
VOC	Vocalizations
FFP	Front Feet Positions
HFP	Hind Feet Positions
MISC	Miscellaneous
NOISE	Outside Noises
IA	Initial Angle
IR (1-5)	Initial Response
TR (1-5)	Test Response
CR (1-5)	Continued Response
RR (1-5)	Recharge Response
IR1, TR1, CR1, RR1	Response Strength
IR2, TR2, CR2, RR2	Response Type
IR3, TR3, CR3, RR3	Response Angle
IR4, TR4, CR4, RR4	Response Delay
IR5, TR5, CR5, RR5	Seconds Delay
ROOM	Room
QUAD	Quadrant
BEGR	Begin relax--min.
TOTR	Total relax--min.
TFC	Time to first charge--seconds
TNUM	Test number
TREP	Repetition number of test

APPENDIX 5. Values of variables on Laboratory Data Form.

BEAR
- (0) Ace--1981
- (1) Ace--1982
- (2) Barney
- (3) Cub--BB
- (4) Davey
- (5) Easy
- (6) Fredda
- (7) George
- (81) Cub #1
- (82) Cub #2

OUTTEMP
- (1) Hot
- (2) Warm
- (3) Cool
- (4) Cold
- (9) No data

OUTCLOUD
- (1) Clear
- (2) Patchy clouds
- (3) Overcast
- (4) Low clouds
- (5) Intermittent rain
- (6) Rain or sleet
- (7) Snow
- (8) Clear with full moon
- (9) No data

OUTWIND
- (1) No wind
- (2) Light wind
- (3) Moderate wind
- (4) High wind
- (9) No data

TPER
- (0) 30 Min. Pre-test
- (1) 30 Min. Post-test
- (2) 30 Min. Pre-control
- (3) 30 Min. Post-control
- (4) No above test
- (5) Test
- (6) Recharge response
- (7) Reapproach
- (9) Baseline

TEST
- (0) Control
- (1) Umbrella
- (2) Flare
- (3) Halt
- (4) Skunker/Halt
- (5) Water
- (6) No above
- (7) Skunker
- (9) Baseline
- (-1) Boat horn
- (-2) Bear tape
- (-4) Rock & roll music
- (-6) Foot stomp
- (-8) Shield

IA
- (0) 0 degree angle
- (1) 30 degree angle
- (2) 60 degree angle
- (3) 90 degree angle
- (4) 90 degree angle
- (9) No data

IR1, TR1, CR1, RR1
- (0) No intensity
- (1) Weak
- (2) Moderate
- (3) Strong
- (9) No data

IR2, TR2, CR2, RR2
- (0) Did not charge
- (1) Repel
- (2) Submissive, no response
- (3) Aggressive
- (4) Charge
- (9) No data

IR3, TR3, CR3, RR3
- (0) 0 degree angle
- (1) ≤30 degree angle
- (2) ≤60 degree angle
- (3) ≤90 degree angle
- (4) +90 degree angle
- (9) No data

IR4, TR4, CR4, RR4
- (0) Immediate reaction time
- (1) Delayed reaction time

ROOM
- (50) Snare

TFC
- (00) Immediate
- (85) Sprayed but no charge
- (88) Never charged

APPENDIX 6. Values of activity class variables on Laboratory Data Form (adapted from Miller 1980).

OVERALL ACTIVITY (OA)

(1) Sleep or quiet
(2) Elimination
(3) Eat or drink
(4) Light activity
(5) Moderate activity
(6) Heavy activity
(7) "Frozen"

GROSS BODY POSITION (GBP)

(1) Lying side
(2) Lying back
(3) Lying belly
(4) Sitting
(5) Sit crouched, hunched
(6) Standing
(7) Standing up
(8) Pull up at door
(9) No data

HEAD POSITION (HP)

(0) Head normal
(1) Head extended
(2) Head curled
(3) Hibernator position
(4) Chin on paw or tire
(5) Head down
(6) Head up
(7) Head low but level
(8) Head shake
(9) No data

HEAD ORIENTATION (HO)

(0) No special direction
(1) Sniffing object
(2) Sniffing self
(3) Eat or drink
(4) Looking up or down
(5) Looking about
(6) Directed to object
(7) Directed stare
(8) "Frozen"
(9) No data

EAR POSITION (EP)

(0) Ears relaxed or up
(1) Ears directed forward
(2) Ears mobile
(3) Ears partly back
(4) Ears flattened

VOCALIZATION (VOC)

(0) None
(1) Deep sigh
(2) Panting
(3) Groan or moan
(4) Hiss
(5) Jaw pop
(6) Chuggling
(7) Growl (moderate)
(8) Growl (vigorous)
(9) No data

FRONT FOOT POSITION (FFP)

(0) Typical
(1) Extend forward, back in air
(2) Spread eagled
(3) On wall or tire
(4) Front feet in well, tray
(5) Curled or tucked
(6) Manipulating objects
(7) Scratching
(8) Split forward and back
(9) No data

HIND FOOT POSITION (HFP)

(0) Typical
(1) Extend forward, back in air
(2) Spread eagled
(3) On wall or tire
(4) In the air, wall, tray
(5) Curled or tucked
(6) Split in the air
(7) Scratching
(8) Extended back
(9) No data

MISCELLANEOUS (MISC)

(0) Snore
(1) Mouth open
(2) Lip extended and canines showing
(3) Biting
(4) Licking
(5) Yawn
(6) Sniffing air
(7) Eyes closed
(8) Digging or sweeping
(9) No data

NOISE (NOISE)

(0) None or faint
(2) Dogs barking
(3) Voices or working outside
(4) Lab door
(5) Truck, car, or motorcycle
(6) Work noises (inside)
(7) Test disturbance
(8) Airplane

APPENDIX 7. Responses to tests by test number for each bear.

BEAR	IMMEDIATE RESPONSE TO STIMULUS	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 (1982)	Did not charge	2		U[a]	U											
	Charged															
	Submissive	5		U	U									F	F	H
	Aggressive	1										F				
	Charge	8	U			U	F	C	C	C	C		F			
	Total	16														

BEAR	IMMEDIATE RESPONSE TO STIMULUS	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14
4	Did not charge	1							F							
	Charged															
	Repel	3			U			F								H
	Aggressive	1		U												
	Charge	9	U			U	F			F	C	C	C	C	W	
	Total	14														

[a] Stimuli tested: C = Control; F = Flare; H = Halt; S = Skunker; S/H = Skunker/Halt; U = Umbrella; W = Water

APPENDIX 7. (Continued).

BEAR	IMMEDIATE RESPONSE TO STIMULUS	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
5	Did not charge	13						F	F	F	S/H	S/H	S/H		S		S	S	H		H	H	U
	Charged																						
	Repel	3												S/H		S				H			
	Charge	5	C	C	C	C	F																
	Total	21																					

BEAR	IMMEDIATE RESPONSE TO STIMULUS	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
6	Did not charge	14	C	C	C	C					S/H	S/H	S/H	S/H	H	H	H	H	H				H
	Charged																						
	Repel	4						F	F												H	H	
	Submissive	1								F													
	Aggressive	2					F													H			
	Total	21																					

BEAR	IMMEDIATE RESPONSE TO STIMULUS	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
7	Did not charge	5							H	H							S/H	S/H	S/H	
	Charged																			
	Repel	4					H	H								S/H				S/H
	Submissive	2												C	S					
	Aggressive	3		F	F						C									
	Charge	4	F			F						C	C							
	Total	18																		

[a]Stimuli tested: C = Control, F = Flare, H = Halt, S = Skunker, S/H = Skunker/Halt, U = Umbrella, W = Water

APPENDIX 8. Black bears tested at the Sparwood sanitary landfill, Sparwood, British Columbia, August-November, 1982.

BEAR	EAR TAGS[a]				LIP TATTOO[b]	COAT COLOR	APPROXIMATE WEIGHT (LBS.) IN SEPTEMBER	AGE CLASS	KNOWN AGE	KNOWN SEX
	Left		Right							
	No.	Color	No.	Color	No.					
Marked										
01	1	white	1	orange	01	Black	130	AD	4.5	M
02	2	orange	2	white	02	Black	130	SA	3.5	M
04	4	yellow	4	orange	04	Cinnamon	175	AD	5.5	M
05	5	orange	5	yellow	05	Black	125	SA	2.5	M
06	6	white	6	yellow	06	Black	125	SA	3.5	M
07	7	yellow	7	white	07	Chocolate brown	155	AD	4.5	M
08	8	yellow	8	yellow	08	Black	175	AD	5.5	M
09	9	white	9	white	09	Black	120	SA	2.5	F
10	10	yellow	10	yellow	10	Chocolate brown	110	SA	2.5	M
Unmarked										
11	Hit on road; shot 9/10/82					Black	130	SA	2.5	M
12						Black	250	AD		
20						Black	130	AD		F
21						Liver brown	60	Cub	0.5	
22						Black	150	AD		F
23						Black	60	Cub	0.5	
30						Black	200	AD		
31						Dark brown	250	AD		
32						Black	130	SA		
33						Light brown	130	AD		
34						Black	130	AD		
35						Black	130	AD		
36						Black	100	Yrl		
37						Black	200	AD		
38						Black	175	AD		
39						Black	150	AD		
40						Black	150	AD		
41						Dark brown	225	AD		
42						Chocolate brown	175	AD		
43						Black	100	SA		
44						Black	225	AD		
45						Black	125	AD		

[a]Ear tags are large plastic cattle tags, approximately 5 x 5 cm in width, and marked on one side only.

[b]Lip tattoos are black; all on the upper lip, generally on the right side of the muzzle.

APPENDIX 9. Test observations- Field Data Form.

LOCATION:
OBSERVERS:
DATE:
TEMP:
CLOUD:
WIND:
DIRECTION:

DUMP SET-UP: (Drawing of location of garbage and tray placement)

BAIT STATIONS:

1 (Stimulus	6
2	7
3	8
4	9
5	10

				DESCRIPTION						TEST RESPONSE									
HR IN	HR OUT	TRAY NO.	BEAR NO.	COLOR	MARKINGS	AGE CL.	WGHT	SEX	APPR	TR1 STGTH	TR2 TYPE	TR3 N	TR4 LOC	TR5 SPEED	DELAY (SEC)	DISTURB	NO. BEAR PRESENT	AM TRAY STATUS	COMMENTS

APPENDIX 10. Labels of variables on Field Data Form.

DATE	Julian Date
TEMP	Temperature--general
CLOUD	Cloud cover
WIND	Wind--general condition
DIRECTN	Wind direction (blowing from)
HOURIN	Time arrive (24 hr.)
MININ	Time arrive (60 min.)
HOUROUT	Time leave (24 hr.)
MINOUT	Time leave (60 min.)
TRAY	Repellent or deterrent tested
BEAR	ID number for individual bear
AGECLASS	Age class for bear
AGEYEARS	Age (lab estimate) of bear
SEX	Sex of bear
WEIGHT	Weight (kg.) of bear
NUMBEARS	Number of bears at site
DISTURB	Disturbance of test
APPROACH	Approach to tray by bear
TR1	Strength of test response
TR2	Type of test response
TR3	Distance (m) retreated
TR4	Location of retreat
TR5	Speed or reaction to test
TR6	Delay time (sec.) for reaction
HOURRET	Reapproach time (24 hr.)
MINRET	Reapproach time (60 min.)
RELOC	Reapproach to location
AMTRAY	Status of tray at 0700 (7 a.m.)
BEARDIST	ID of bear is cause of disturbance

APPENDIX II. Values of variables on Field Data Form.

BEAR
(0) Unidentified
(99) No data

TEMP
(1) Hot
(2) Warm
(3) Cool
(4) Cold
(9) No data

CLOUD
(1) Clear
(2) Patchy clouds
(3) Overcast
(4) High clouds
(5) Intermittent rain
(6) Rain or sleet
(7) Snow
(8) Clear with full moon
(9) No data

WIND
(1) No wind
(2) Light wind
(3) Moderate wind
(4) High wind
(9) No data

DIRECTN
(0) No wind
(1) N
(2) NE
(3) E
(4) SE
(5) S
(6) SW
(7) W
(8) NW
(9) No data

TRAY, RELOC
(9) Garbage pile
(1) Control 1
(2) Control 2
(10) Mothballs—on
(11) Mothballs—around
(20) Technichem—on
(21) Technichem—around
(30) Urine, Fem—on
(31) Urine, Fem—around
(40) Urine, Male—on
(41) Urine, Male—around
(50) Boundary—on
(51) Boundary—around
(60) Ammonia, Parsons—on
(61) Ammonia, Parsons—around
(70) Ammonia, Wizard 1—on
(71) Ammonia, Wizard 2—on
(80) Skunker—on
(81) Skunker—control
(82) Skunker—trigger
(90) Halt—control
(92) Halt—trigger
(93) Area perimeter
(94) Pit
(95) On site
(99) No data

AGE CLASS
(0) Unknown
(1) Adult
(2) Subadult
(3) Yearling
(4) Family group (cub)
(5) SA to AD
(6) YRL to SA
(9) No data

AGE YEARS
(00) Unknown
(99) No data

SEX
(0) Unknown
(1) Female
(2) Male
(9) No data

DISTURB
(0) No disturbance
(1) Vehicle dumping
(2) Vehicle on site
(3) Train
(4) Lights from vehicle
(5) Lights from flashlight
(6) People on site
(7) Bear to area
(8) Bear to location
(9) Our work noise
(10) Snow
(11) Rain
(12) Wind
(13) Other bear hit with test
(14) Heavy smoke
(88) Unknown disturbance
(99) No data

APPROACH
(0) Unknown
(1) Avoid
(2) Walk by
(3) Sniff and walk by
(4) Indirect investigation
(5) Direct investigation
(9) No data

AMTRAY
(0) Empty
(1) Less than half left
(2) More than half left
(3) Full

APPENDIX 12. Values of test responses on Field Data Form.

TR1
- (1) Strong intensity
- (2) Moderate intensity
- (3) No intensity
- (4) Weak intensity
- (9) No data

TR2

Passive
- (1) Walk away; no eat
- (2) Eat briefly; leave
- (3) Eat hesitantly
- (4) Eat continuously

Triggers
- (1) Run away
- (2) Walk away
- (3) Orient to; eat hesitantly
- (4) Orient to; eat continuously

TR4
- (0) Unknown
- (1) Left site
- (2) Site perimeter
- (3) To garbage pile
- (4) To another tray
- (5) To same tray
- (6) To our truck
- (99) No data

TR5
- (0) Immediate reaction
- (1) Delayed reaction
- (9) No data

APPENDIX 13. Total number of days individual bears within each age class were observed at the dump site during the test periods.

ADULT			SUBADULT			FAMILY GROUP (CUBS)		
Bear	Days present N	%	Bear	Days present N	%	Bear	Days present N	%
0[a]	2	(10)	2	7	(33)	21	9	(43)
1	1	(5)	5	11	(52)	23	6	(29)
4	12	(57)	6	1	(5)			
7	3	(14)	9	6	(29)			
8	9	(43)	10	15	(71)			
12	10	(48)	11	5	(24)			
20	9	(43)	32	1	(5)			
22	6	(29)	35	8	(38)			
30	2	(10)	36	3	(14)			
31	1	(5)	43	1	(5)			
33	7	(33)	66[b]	1	(5)			
34	1	(5)						
37	1	(5)						
38	6	(29)						
39	6	(29)						
40	8	(38)						
41	6	(29)						
42	1	(5)						
44	1	(5)						
45	1	(5)						
88[c]	1	(5)						

[a]Unidentified bear.

[b]Unidentified adult.

[c]Unidentified subadult.

APPENDIX 14. Number of visits to each stimulus by individual bears within each age class.

STIMULUS	ALL BEARS	NUMBER OF VISITS BY EACH BEAR: Adult																						Subadult												Cubs		
		N	0[a]	1	4	7	8	12	20	22	30	31	33	34	37	38	39	40	41	42	44	45	88[b]	N	2	5	6	9	10	11	32	35	36	43	66[c]	N	21	23
Control 1	52	22			2		1	9					3				1	3	2				1	26		11		3	8			3	1			4	4	
Control 2	29	16			1		3	3	1				1			2		1			4			9	2	4			1	1				1		4	4	
Boundary--on	25	13			1			4			1		4			2		1						11	1	2		1	2	3		2				1	1	
Boundary--around	18	5						3					1									1		13		1			7	3		2						
Mothballs--on	24	12			1	1		1					2			2	1	2				1	1	12		2		2	6	1	1							
Mothballs--around	19	6			1			2			1				1		1							13		1		1	7	2		2						
Technichem--on	19	6						2						2				1				1		13		3			4	2	2	1			1			
Technichem--around	33	17			1		1	5			1	1	5			1	1	1						16	1	2			8			4	1					
Urine, Male--on	23	9						6					1				1					1		13	1	2		2	5	1		1			1	1	1	
Urine, Male--around	37	21			4		1	2	1		2	1	5		2		1	2						15	1	5			6	2		1				1	1	
Urine, Fem--on	8	4			1		1	1										1						3		3										1	1	
Urine, Fem--around	16	11			2			2								1	3	3						1								1				4	4	
Ammonia, Parsons--on	6	2						1										1						5		1		2		1								
Ammonia, Parsons--around	18	9	1				2	1	2								2		1					8		4		1	1	2						1	1	
Ammonia, Wizard 1--on	19	13			6					3								2	2					6		2			3			1						
Ammonia, Wizard 2--on	22	11			2			1		4								2	2					6		1			4			1				5	1	4
Skunker--on	24	13	1		1		1	2	1							2	1		2	2				10		7				1		1		1		1	1	
Skunker--control	13	2			2																			11	2	4			1			2	2					
Skunker--trigger	37	15	1		5			1		2							1	1	2		2			18	2	10			1			5				4	4	
Bait--control	12	6			1				1				2					1					1	4		2			1	1						2	2	
Bait--trigger	21	10					1	1					1					1	1		3			11	1	5			4				1					
Total visits by bears	475	221	3		31	1	11	47	6	9	5	2	25	2	3	10	13	23	12	2	9	4	3	223	11	72		12	69	20	3	27	5	2	2	29	25	4

[a]Unidentified bear.
[b]Unidentified adult.
[c]Unidentified subadult.

APPENDIX 15. Reaction of bears after being deterred/repelled by each stimulus.

TEST	N	NO DATA	LEFT SITE	TO SITE PERIMETER	TO GARBAGE PILE	TO ANOTHER TRAY	TO SAME TRAY	TO OUR TRUCK
Control 1	13		1[a] (8)[b]		2 (15)	8 (62)	2 (15)	
Control 2	4		2 (50)			1 (25)	1 (25)	
Boundary--on	7					5 (71)	1 (14)	1 (14)
Boundary--around	1					1 (100)		
Mothballs--on	5			1 (20)	1 (25)	2 (40)		
Mothballs--around	1					1 (100)	1 (20)	
Technichem--on	1					1 (100)		
Technichem--around	3				1 (33)	2 (67)		
Urine, Fem--on	4		1 (25)			3 (75)		
Urine, Fem--around	2					2 (100)		
Urine, Male--on	18	2 (11)				12 (67)	4 (22)	
Urine, Male--around	14	1 (7)			4 (29)	9 (64)		
Ammonia, Parsons--on	4					4 (100)		
Ammonia, Parsons--around	10					7 (70)	3 (30)	
Ammonia, Wizard 1--on	6					6 (100)		
Ammonia, Wizard 2--on	5				3 (60)	2 (40)		
Skunker--on	5				1 (20)	3 (60)	1 (20)	
Skunker--control	4				1 (25)	2 (50)	1 (25)	
Skunker--trigger	20	1 (5)	4 (20)	3 (15)	1 (5)	6 (30)	5 (25)	
Halt--control	3		2 (67)	1 (33)				
Halt--trigger	18	1 (5)	10 (56)	2 (11)	2 (11)	3 (17)		

[a]Number of occurrences.

[b](Percent).

APPENDIX 16. Deterrents, aversive conditioning, and other practices: an annotated bibliography to aid in bear management.